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[THIRD SERIES.]

Art. XXXVI.—*Spectroscopic Notes;* by Professor C. A. Young, Princeton, N. J.

For the past few months I have been examining the spectra of sun-spots with great care, and with an instrument of high dispersion.

The spectroscope employed consists of a comet-seeker of five inches aperture and about forty-eight inches focal length, used both as collimator and view-telescope after Littrow's method, the slit and diagonal eye-piece being as close together as it is convenient to place them. A small spot of black paper, about three-tenths of an inch in diameter, is cemented to the center of the object-glass (as suggested by my colleague, Professor Brackett, in a note published in this Journal, July, 1882), and entirely destroys the internal reflections which would otherwise most seriously interfere with vision.

The dispersion is obtained by one of Professor Rowland's magnificent gratings on a speculum-metal plane, with a ruled surface three and one-half inches by five; 14,000 lines to the inch. The slit and eye-piece of the telescope are so placed that the line joining them is parallel to the lines of the ruling. An instrument of this sort is incomparably more convenient than one in which the collimator and view-telescope are separate, though of course, on account of the inclination of the visual rays to the axis of the object-glass, there is a little aberration, and the *maximissimum* of definition is not quite reached. There is no difficulty, however, in seeing easily the duplicity of the

b's, E_1 and other similar tests, with the instrument thus arranged. The spectroscope is mounted upon a strong plank, stiffly braced, and this is attached by powerful ring-clamps to the tail-piece of the twenty-three-inch equatorial of the Halsted observatory, so that the image of the sun falls directly upon the slit.

The detailed examination of the spot-spectra has been thus far confined mainly to a few limited regions in the neighborhood of C, D and *b*.

With the high dispersive power employed, the widening and "winging" of the heavier lines of the spectrum is not well seen, not nearly so well as with a single prism spectroscope. All diffuse shadings disappear much in the same way as the naked eye markings on the moon's face vanish in a powerful telescope—to be replaced by others more minute but not less interesting. In a few spots, however, the broadening of the D's and the reversal and occasional "lumping" of C has been noticeable even with this high dispersion. But the most striking result is that in certain regions the spectrum of the spot-nucleus, instead of appearing as a mere continuous shade, crossed here and there by markings dark and light, is resolved into a countless number of lines, exceedingly fine and closely packed, interrupted frequently between E and F (and occasionally below E) by lines as bright as the spectrum outside the spot. These bright lines, so far as the eye can determine, may be either real lines *superposed*, or merely vacancies left in the shading of fine dark lines, since they are not sensibly brighter than the ordinary background of the surrounding spectrum.

The darker and more intense the spot, the more distinctly the fine lines come out, both the bright and the dark; and so far as I have been able to make out yet, there is no difference as regards these fine lines between one spot and another. I have never yet seen any evidence of displacement in them due to motion, no "lumpiness" nor want of smoothness in them.

When seeing is at the best, and everything favorable, close attention enables one to trace nearly all these lines out beyond the spot and its penumbra. But they are so exceedingly faint on the sun's general surface that usually they cannot be detected outside the spot spectrum. This resolution of the spot-spectrum into a congeries of fine lines is most easily made out in the green and blue. Near D, and below it, it is much more difficult to see, and I am not even quite sure that this structure still exists in the regions around C and below it. Here, in the red, even with the highest dispersion and under the most favorable circumstances of vision, the spot-spectrum appears simply as a continuous shade, crossed here and there by widened and darkened lines, which, however, are very few and far between

as compared with the number of such lines in the higher regions. Of course the resolution of the spot-spectrum into lines tends to indicate that the absorption which darkens the center of a sun-spot is produced, not by granules of solid or liquid matter, but by matter in the gaseous form, and it becomes interesting to inquire what substances are capable of producing such a spectrum, and under what conditions. As to the fineness and number of the lines, it may be noted that in the region included between b_1 and b_4 the single lines appear to be each about half as wide as the components of b_3, and are separated by an interval about one-third as great. The whole number between b_1 and b_4 must be over a hundred, though they are of course very difficult to count with accuracy. They are a little wider in the middle of the spot-spectrum, in fact spindle-shaped, running out into extremely fine threads where they pass into the penumbra, and in my instrument they seem to be a little more hardly and sharply defined on the upper (more refrangible) edge than on the lower.

The bright lines, of which there are six between b_1 and b_4, are generally about as wide as the interspace between the components of b_3. They are sharply defined at both edges, and no brighter at the center than at the edge, a fact which rather bears in favor of the idea that they are merely interruptions in the dark line series, and not really superposed bright lines. Just above b_4 (at λ 5162·3) there is a very conspicuous one, which is also noticeable enough in the ordinary solar spectrum. Attention has indeed been frequently called to it long since by other observers. Below E these bright lines are rare. Higher up in the spectrum, between F and G, they become very numerous.

I have also made a considerable number of observations upon prominences with the nine and one-half inch equatorial and its own spectroscope. There have been lately numerous very fine exhibitions, especially in connection with the spots. The number of lines reversed in the spectrum of the chromosphere has at times been very great, far exceeding the number observed and catalogued in 1872, but I have not been able to detect a single *new* one below C, though the two mentioned in my catalogue have been seen almost continuously. On two occasions—July 31st and August 1st—a new line above H (λ 3884±2) was conspicuously visible for an hour or two each time, during a specially vigorous eruption of the prominences associated with the great spot which was then just passing off the limb. This line was seen easily without the aid of any fluorescent eye-piece, and I am satisfied that on a photographic plate it would have been more brilliant than either H or K. I could not determine its position within one or two units on account of the difficulty of identifying the numberless fine lines around it.

With the widened slit it showed clearly the form of the lower part of the prominence, but not the upper. It was almost precisely imitated by two new lines at λ 4092 and 4026; and the catalogue-lines 4077 and 3990 resembled it also. On the other hand, *h*, H and K showed the higher parts of the prominence as well as the lower, while the lines at 4045 and 3970 were exceedingly fine and smooth, without knottiness or structure.

On August 1st, at $2^h\ 58^m$ local time ($=7^h\ 57^m$ Greenwich time), the intensity of the chromosphere spectrum was very remarkable, the bright lines more vivid and numerous than I remember ever to have seen them before. Between this time and 3.12 a prominence was shot up in fragments of flame to an elevation of over 120,000 miles. It will be interesting to learn whether any corresponding magnetic twitch appears on the magnetometer records.

Princeton, N. J., Sept. 10, 1883.

ART. XXXVII.—*On Meteoric Iron from near Dalton, Whitfield County, Georgia;* by CHARLES UPHAM SHEPARD, SR.

WHETHER the mass here described is of identical origin with that found in 1877, and described by Mr. W. Earl Hidden in vol. xxi, No. 124, p. 287, of this Journal, is not quite certain. The circumstances connected with the finding of the present mass are detailed in the following letter of H. C. Hamilton, Esq., of Dalton, dated Oct. 18th, 1882, addressed to Major E. Willis of Charleston, S. C.:

"*Sir*—Yours of the 14th inst. from Professor Charles U. Shepard, Jr., in regard to the meteorite is received. The meteorite was found some time in the year 1879 by Francis M. Anderson, on his farm, on lot 109 in the 10th district and 3d section of Whitfield county, Georgia, about 14 miles northeast of Dalton. It was discovered while plowing, on the west side of a ridge, near its base. The ridge runs north and south, and the furrows cut east and west. It was lying with its apex upward, and buried about six inches below the surface of the ground.

Some time during the fall of 1860 an unusual atmospheric phenomenon occurred in the region. A bright light shot across the heavens, followed by a loud report, creating great alarm among the people, many of whom supposed the end of the world had arrived.

A large mass of iron, supposed to be a meteorite, was found half a mile from this one, about the year 1862. It was sent

to Cleveland, Tennessee, where it appears to have been lost sight of, as nothing further can be ascertained respecting it."

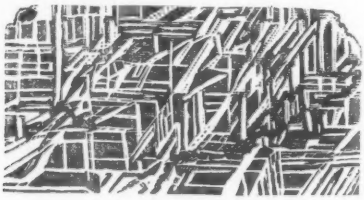
The mass now described belongs to the meteoric collection of C. U. Shepard, Jr., of Charleston, S. C. Its weight is 117 pounds.

The wood-cut shows its general shape, which is somewhat that of a pear, whose apex is slightly trihedral. The surface is nearly black, and very little oxidated. It is destitute of deep indentations; and presents a surface with only faint, wave-like depressions.

It is more easily divided with the saw than most other irons, owing to the absence of pyritic veins and kernels. When broken across a thickness of $\frac{1}{8}$th of an inch, it presents a coarse, but highly uniform, granular structure, and shows a cleavage of the individuals, much resembling that of the Braunau iron. Its polished surfaces are almost perfectly homogeneous, being wholly free from amygdaloidal inclosures. At places within an inch of the outside however, a few very thin, black, thread-like veins occur, apparently the products of shrinkage in the process of cooling. The substance of these veins is partly the oxides of iron, with which is intermingled a trace of chlorine, the latter probably derived by infiltration from the soil. The deliquescence of the polished surfaces is confined to these black seams.

The Widman figures present a rather remarkable feature. In the annexed wood-cut they are copied from an actual impression derived from an etched surface of the iron, with the omission only of the finer lines that enclose the white bars and traverse the shaded parallelograms and triangles. The fine lines are not introduced owing to the difficulty of their proper representation on wood. The peculiarity of the pattern consists, as the wood-cut shows, in the tendency in one series of bars to

cross each other at right angles, while in a second series, less uniform in width, they pass diagonally (in descending) from right to left across the shaded spaces.



The shaded portions are in no way different in composition or structure from those which are in white, as may be seen by receiving the light from them on the polished metallic surfaces at a slightly different angle. This changeability doubtless depends upon a crystalline structure analogous to that producing a similar effect in numerous crystalline minerals, particularly in the family of feldspars.

On etched surfaces, the schreibersite shows in exceedingly thin and nearly straight continuous lines, though they are occasionally interrupted at short intervals, when they resemble the markings on telegraphic ribbands. The continuous lines sometimes swell into triangular or polygonal enlargements, forming a string of nearly disconnected beads, as represented by G. Rose in the Zacatecas iron. These beads he denominates crystals.

The specific gravity of the iron is 7·986, a density somewhat higher than common in meteoric irons, but not unexpected in one like the present, destitute of sulphur and containing less phosphorus than usual in these bodies.

The analysis of C. U. Shepard, Jr., gave

Iron	94·66
Nickel	4·80
Cobalt	0·34
	99·80

With phosphorus, chromium and manganese in traces.

It is to be regretted that we are unable to decide whether this meteorite belongs to the same fall with the 13-pound mass described by Mr. Hidden. The two were found at different times, several miles asunder, and were totally unlike in the character of their surfaces. Besides, the smaller abounded in chlorous deliquescence; and it appears to have been easily separated by cleavage, suggesting a longer contact with the soil.

ART. XXXVIII.—*Notice of Corundum Gems in the Himalaya region of India;* by CHARLES UPHAM SHEPARD, SR.

THE discovery of a remarkable locality of the sapphire and ruby in the Himalaya Mountains has been communicated to me by Rev. M. B. Carleton of Keoloo, India, a former pupil of mine, and graduate in 1877 of Amherst. He derived his information from the following descriptive note of Mr. Grahame Young of Kulu.

"There are two versions of the discovery of the corundum deposits at Sungchang in Zanskar, one being that they were exposed by a hill-side slipping, the other that they were discovered by hunters. Their value was so little known that the villagers bartered them for a trifle to Lahouli traders, who in their turn vainly endeavored to exchange them for grain in Kulu. On their value becoming known, there was a rush of jewelers from Delhi and other places; and they speedily rose to 100 rs. per tola = about £20 stg. per oz., for good specimens, at which rate they have remained; at present none are to be had, all the stock brought down has been sold, and the mine is strictly guarded by one of the Maharajah's Dogra regiments.

So far as I can learn, the matrix is a schistose or slaty rock. The vein consists of

I. Ordinary quartz crystals, some very large.

II. A few crystals of amethyst.

III. Deep blue corundum of a beautiful water, very rough externally, no crystal more than 4 inches long; sp. gr. 3·985.

IV. Corundum, sapphire-colored only in the middle, shading lighter until both base and apex are perfectly limpid.

V. Perfectly limpid corundum.

VI. Black corundum.

VII. Opaque white corundum, sapphire tinge in places, small black crystals (probably tourmaline) imbedded. All the above are beautifully crystallized, apex very acute.

VIII. Massive corundum, both black and opaque white.

IX. Chlorite, crystals imperfect.

X. A little magnetite.

The Maharajah has recently released from prison and largely rewarded two native hunters, who had been imprisoned for dealing in sapphire, on condition of their showing him two other deposits, one of *blue* and the other of *red* corundum. I have no information regarding these deposits.* A small fragment of the red corundum has, however, found its way to

* And up to this time, May 22, 1883, I have heard nothing further concerning them.—W. B. CARLETON.

Kulu; it is true oriental ruby, perfectly clear, and of a beautiful water.

The facts I have collected regarding the first discovered deposit are derived from an examination I made of about an hundred weight of the crystals; their owner would not allow me to apply any tests, but I used a compound lens magnifying 30 diameters. A. GRAHAME YOUNG.

Kulu, Aug. 8, 1882."

The discovery has the greater interest for us owing to certain analogies in the mode of occurrence and some other particulars between the crystals found in India and those produced at several of the American localities. These resemblances are the most striking between the Indian specimens and those of Laurens district, South Carolina. At this latter place the crystals are enclosed in a highly micaceous schist as well as found loose in the contiguous soil; they are very abundant; of the same size, surface and form as those described by Mr. Young; possess a similar coloration except with greatly inferior tints of blue and red; but are traversed by abundant cleavage flaws and destitute of transparency.

The Pelham, Massachusetts, corundum, which, however, is by no means abundant, closely resembles that of Laurens, except that it is imbedded in a scaly biotite intermingled with vermiculite and ripidolite, with occasional inclosures of anorthite seams.

The crystals of the Burke and Iredel county region of North Carolina, though considerably different, still remind us of those from Laurens. So far as I know they are only loose in the soil. They vary from one to four inches in length, are generally pyramidal in form and coated by a glaze of gray muscovite, as though they had originated in mica-slate. Numbers of them, and generally of larger size, are hexagonal prisms, and thickly drused over with short implanted crystals of white margarite. Indeed, nearly all the crystals from this region, when broken across, exhibit an exterior annulus of this species, while the interior is distinctly stellated; and when the surface is polished a copper-colored chatoyement is sometimes presented. The colors of the Iredal crystals are less intense than those of Laurens or Pelham.

The only analogy between the Indian crystals and the sapphire and ruby of Macon and Clay counties, of North Carolina, consists in the association of ripidolite with both.

The resemblances here pointed out appear to me sufficiently important to encourage the expectation that valuable corundum gems may yet be found in the United States.

New Haven, July 19, 1883.

ART. XXXIX.—*Phenomena of the Glacial and Champlain periods about the mouth of the Connecticut valley—that is, in the New Haven region;* by JAMES D. DANA.

THE Glacial phenomena over the New Haven region have many points of special interest, an important part of which arise from the fact that the ice of northern New England which had moved down the Connecticut valley or trough, here left the mainland for a passage through Long Island Sound. The subject includes therefore a discussion of the relations between the part of the glacier to the north and that over the Sound and beyond, and suggests questions as to—

(1) The thickness of the glacier at this southern end of the trough, and the pitch along the trough.

(2) The fact or not of two directions of movement in the ice —a *lower* or *trough stream* south-southwestward, and an *upper stream* southeastward; and, if two, as to their being simultaneous or not.

(3) Any mixing of drift materials from the two streams.

(4) The direction of movement after escaping from the confines of the Connecticut trough and entering the east-and-west trough of the Sound.

(5) Any effects in the New Haven region consequent on a change of direction in the glacier-movement.

The phenomena also of the early Champlain period, when the floods from the dissolving glacier were pouring down the valley and made use of New Haven Bay for the outlet of part of the waters—repeating the drainage conditions that existed long before in Triassic time—have a wide bearing, especially those connected with—

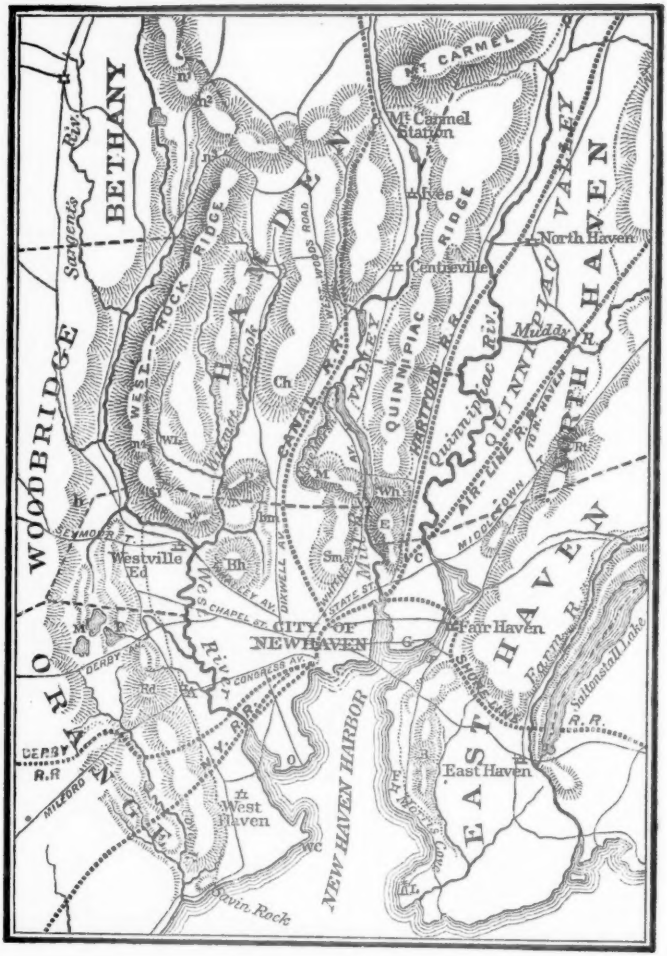
(1) The structure and seaward slope of the New Haven terrace-formation, or the deposits of stratified drift which underlie the broad New Haven plain.

(2) The occurrence, over the flood-made fluvial deposits of the plain, of more than forty isolated basin-shaped cavities called "kettle-holes."

(3) The existence also of two broad north-and-south depressions in the plain, each over a mile long, which look like deserted river channels.

(4) The apparent connection of these depressions and the "kettle-holes" with a former system of drainage, characteristic of the Glacial era.

(5) The existence of a terrace on the bay, testifying to the sea-level during the era of the flood.



MAP OF THE NEW HAVEN REGION. Scale 4-10ths inch = 1 MILE.

Explanations.—A, Allingtown. B, Beacon Hill. Bh. Beaver Hills. Ch, Cherry Hill. E, East Rock range, consisting of East Rock to the north, next south Indian Head, and further south Snake Rock. Ed, Edgewood. F, Fort Hale. *F*, Ferry Point, or Red Rock, on the Quinnipiac. G, Chapel Street. J, Judges Cave, on the West Rock ridge. L, Old Light House. M, Mill Rock. M P, Malthy Park. O, Oyster Point. P, Pine Rock. Rd, Round Hill. Rt, Rabbit or Peter's Rock. Sm, Sachem's ridge. T, Turnpike: also Tomlinson's bridge, across the head of New Haven Bay. V, Whitneyville. W, West Rock, the south end of West Rock ridge. W C, West Cape, or West Haven Point. Wh, Whitney Peak. W L, Wintergreen Lake. *b*, 1200 ton bowlder in Woodbridge. *bm*, Beaver Pond Meadows. *n1*, *n2*, *n3*, *n4*, different notches in the West Rock ridge; *n1*, *n2*, the upper and lower Bethany Notches; *n3*, the Hamden Notch; *n4*, the Wintergreen Notch.

Some of these points were discussed by me in 1870, in a paper on "the Geology of the New Haven Region," published by the Connecticut Academy of Sciences in the second volume of its Transactions. But since that time many new facts have come to light, sustaining some of the conclusions then presented and requiring modifications of others, besides affording fuller illustrations of all the various characteristics of the plain. Further, in the interval which has elapsed, a topographical survey and chart of the region have been made under the auspices of the Coast Survey and the special superintendence of Mr. R. M. Bache, assistant U. S. Coast Survey, laying down the features of the surface with great accuracy, and indicating the level over the whole area by 20-foot contour lines. In my endeavor to secure such a survey, I had especially in view its use as a basis for geological investigations and reports; and it fulfills well the purpose. Moreover, it has brought to view new facts, and given greater precision to our knowledge of topographical details. A review of the subject with the aid of all the additional light obtained is therefore needed.

On the preceding map, the *New Haven region* comprises all of the area south of the trap-and-sandstone range of Mt. Carmel, and east of the range of hills of metamorphic schists which make its western border through the towns of Orange, Woodbridge and Bethany.

The *western* border region has a rather abrupt eastern front, and rises in height from 100 feet above mean-tide level on the south to 650 feet on the north. This western border was the western margin of the deep Connecticut trough and estuary of Triassico-Jurassic time, all the rocks of the region eastward of it being trap and sandstone of that era; and it was the occasion of important results also in the Glacial and Champlain periods. South of Westville it is a *double* ridge—that of a broken-backed anticlinal—a shallow valley of ledges and marshes (one-fourth to three-fourths of a mile wide) separating an eastern and a western range of hills.*

The outline of the flood-made terrace-formation is indicated on the map by a dotted line, at the base of the hills. As is seen, the three principal valleys and former flood-ways of the region—West River, Mill River and the Quinnipiac—open southward into the broad New Haven plain. The Quinnipiac valley is separated from that of Mill River by the Quinnipiac ridge, made of sandstone hills 100 to 250 feet in height, with East Rock ridge, 362 feet in greatest height, at its south end; and Mill River valley from that of West River, by the "West Rock Ridge" of trap (doleryte) 400 to 600 feet in height, together with the various sandstone hills that lie to the east of it.

* The valley is called (from one portion of it at M on the map) Maltby Park valley. See also the map on page 358.

On the eastern margin of the region the hills are of trap and sandstone; the largest of the trap ridges constitutes the western border of Lake Saltonstall.

After this introduction, I will take up, first, the phenomena of the Glacial period, discussing the points in the following order:

1. The fact of a southward (S. by W.) movement in the *lower* ice of the glacier along the Connecticut valley, and the angle of slope of the surface of the ice in the direction of the valley.
2. The fact of a *southeastward* movement (S.S.E. to S.E.) in the *upper* ice.
3. The correlations of the two movements as to time and as to drift depositions.
4. The direction of movement over Long Island Sound.
5. The drift deposits, and the probable effects of the wrenching attending the change of direction which they exhibit.

I. Glacial Phenomena.

1. *The fact of a Connecticut valley movement and the probable surface-slope of the ice in the direction of the valley.*

a. The fact of the valley movement.—The fact of the valley movement I pointed out in 1871,* basing the conclusions on (1) observations in Massachusetts, by Professor Edward Hitchcock, published in the Massachusetts Geological Report (1841), (2) observations in Vermont, from the Vermont Geological Report (1861), made chiefly by Professor C. H. Hitchcock, (3) a map of New Hampshire by the latter, giving the directions of glacial scratches, published in advance of the final Report on the Geology of that State, and (4) on my own investigations. The facts supplied by Professor Edward Hitchcock, the earliest careful investigator of the subject on the continent, were sufficient alone to establish the truth announced; and he recognized it, but made the ice mainly that of icebergs. The same conclusion is presented in the Vermont Report. But in the New Hampshire Report, published in 1878, the movement is made by Professor C. H. Hitchcock a *glacier* movement.

The fact *is proved by the glacial scratches.* All observations from New Haven northward to Windsor in Vermont, 140 miles, give, with rare exceptions, courses between S. and S. 20° W. In the upper part of the valley, north of Windsor to Wells River, 60 miles, both southward and southeastward directions occur.

It *is proved also by the drift transportation.* Of the drift material in the New Haven region, more than 99 per cent, including bowlders innumerable, from one ton to 1200 tons in weight,

* This Journal, II, li, 233.

were derived from the trap and sandstone *of the valley*, that is, were taken up in the valley and transported along the valley. The proof is hence positive that the transporting agent moved down the valley, gathering the stones and earth by the way, and, sooner or later, depositing also by the way. The mean course of the Connecticut valley in Connecticut, from the Massachusetts boundary to New Haven bay, is S. 17° W., and this is about the mean course of the scratches and drift.

b. Directions of the bottom movement over the New Haven region; the large amount of WESTING *along the western border and beyond over Orange and Milford.*

The glacial scratches in the eastern part of the New Haven region, over East Haven, about the various opened quarries, indicate a movement in the direction S. 13° W. The usual trend of the sandstone ridges of East Haven is about the same, showing that they owe their forms to glacier abrasion. Sachem's Ridge (Sm on the map), made into a ridge by the ploughing glacier,* because of the protecting Mill Rock to the north, has a trend of S. 11½° W. In Hamden, farther north, the "Quinnipiac Ridge" (similarly carved out by the glacier because under the lee of Mt. Carmel) has the mean course S. 16° W. The valleys and sandstone ridges west of this ridge have nearly the course of the West Rock ridge to the west of them, or S. 26° W.† Along the western border of the New Haven region, in Orange, the course at the many scratched ledges is S. 26°–38° W., and mostly S. 33° W. But it varies over Maltby Park, (M on map) to S. 45° W. and S. 56° W. owing to local conditions.

The large amount of westing on the western border was pointed out in my paper on the New Haven region of 1870; but I have now the additional fact that the course S. 33° W. occurs to the westward of this border over Orange and Milford, for half a dozen miles from the New Haven region, or nearly to the Housatonic and Naugatuck valleys, showing that the southwestward movement had a wide westward extension. The fact points, I suppose, only to near uniformity of direction in the low and broad valleys and ridges of the surface; and proves that the topography, notwithstanding the fact that the rocks are fragile slates, was of pre-Glacial origin.‡

* Ploughing deeply over the soft sandstone formation, but feebly abrading over the trap.

† An exception as to westing occurs two miles north of Westville in the narrow West River valley, where the course of grooving over the slate rocks is South; an exceptional course evidently due to the form of the surface at the place.

‡ Many variations in the directions of glacial scratches are due simply to the varying slopes in the land-surface underneath. The variations usually found about a knoll are an example on a small scale. Only when the slopes of the land-surface and upper glacier-surface coincide in compass-course, will the scratches have the direction of the glacier-flow. If these surfaces are oblique to one an-

The positions of the great bowlders and of the accumulations of drift correspond as to the amount of westing with the courses of the scratches.

The larger bowlders of trap and sandstone lie in the *western* half of the New Haven region. Further, they are gathered in great numbers, together with thick deposits of till, along the hilly *western border*, and especially the *eastern declivity of the high border*—as if moraine-like in origin. But some bowlders of large size occur on the top and eastern declivity of the West Rock ridge, which is one to two miles east of that western border, and a few are found farther east.

One of the largest of the trap bowlders, called the Judges' Cave, lies on the top of the West Rock ridge (at J, a mile north of Westville), at a height of about 365 feet, where it was probably stranded because 25 feet too low in the ice to clear the top of the ridge. It is now in a few large pieces, probably through the rending action of growing trees, but weighed when entire at least 1000 tons. Just a mile west of the "Judges' Cave" on the Woodbridge declivity, lies a still larger bowlder of trap and entire, its extreme length 42 feet, and estimated weight 1200 tons. The spot where it rests is about 360 feet above the sea-level, and 20 feet below the summit beyond it. But a few rods south lies another of 100 tons, and a few hundred yards to the north there is a group of five great trap bowlders, the largest about 200 tons in weight, that were similarly stranded—a most impressive assemblage. Three-fourths of a mile north *on the same declivity* lies another bowlder of 500 tons. Many more of great size—500 tons to 10 (equivalent to 6000 cubic feet to 120), occur both north and south along this border. Further, very few trap bowlders of large size passed its summit. One, measuring $13\times9\times5$ feet, lies a mile west of it in southern Woodbridge; a group of others, the largest $17\times15\times5$ feet, at the same distance nearly, in northern Woodbridge; and one of $8\times5\times7$ feet in northern Orange, west of Maltby Park. Smaller trap bowlders or stones however, with others of sandstone are widely distributed for three to six miles in that direction; on the south they reach beyond Milford.*

The *course of travel* of some of these great bowlders can be made out quite closely. They were derived either from the

other, the scratches at bottom will have an intermediate direction, which will be determined by (1) the angles of the two slopes, (2) the angle between the dip-directions, and (3) the thickness of the overlying glacier. (The velocity was too small to be included.) Hence, some variations in the direction of scratches in a given region are to be expected rather than perfect uniformity, even where there are no defined troughs or valleys.

* A trap bowlder, measuring $15\times8\times6$ feet, lies near the Housatonic River above the railroad crossing; but it is probably from a dike that intersects the metamorphic rocks from southern Woodbridge to the mouth of the Housatonic.

West Rock Ridge or from some part of the Mount Tom range* to the north; for the more eastern trap ridges are too far east. They are, for the most part, alike in consisting of *fine-grained much-rifted* trap, the variety that occurs only as the *outside* of the ejected trap-masses where the melted rock was *rapidly cooled* against the sandstone or air. Hence they probably came from the *top* of the ridges, for the sloping eastern side is now usually under sandstone to within 100 feet (in height) of the top, and the western is that of the bold columnar front.

The trap ridges projected upward into the ice abruptly, several hundred feet—the Mt. Tom ridge (or that from Meriden to Mt. Tom in Massachusetts) probably 600 to 900 feet; a most favorable condition for the successful rending and grasping work of the glacier. The Mt. Tom ridge is 996 feet high (Guyot) in South Mountain, Meriden, 985 feet in Talcott Mountain, west of Hartford, and 1214 feet in Mt. Tom. Some of the fallen masses at the base of its bluffs near Meriden are as large as the largest of the bowlders. Moreover, the trap (doleryte) of this western trap range in Connecticut is mostly a hard, durable rock, while that of the more eastern trap range is generally a hydrous or chloritic kind, very decomposable, and having usually only small chips as its fallen masses. This is one reason why large trap bowlders are rare to the eastward.

The "Judges' Cave" certainly came from the Mt. Tom ridge,—either the main ridge or those subordinate to it, and either from the vicinity of Meriden (16 miles distant), or some point farther north. The trap beneath it is very unlike that of the bowlder. If from the Mt. Tom ridge, the direction of travel was between S. 22° W. and S. 12° W.—the latter if from the northern half of the ridge.

The 1200-ton bowlder, near the top of the Woodbridge border, was probably from nearly the same source, the rock being closely the same; and its course was therefore between S. 24° W. and S. 16° W. If the former, it had passed over the West Rock ridge, at a height of at least 500 feet; if the latter, its course was west of this ridge.

Supposing, in the case of each of these bowlders, the height whence taken to have been 900 feet, the former had sunk in the ice before landing 550 feet, and the latter 540 feet. A 500-ton bowlder that must have had the same course with the "Judges' Cave" and may have been its near companion in the ice, continued on *over the West Rock ridge* and now lies S. 21° W. of it, a mile and a half farther south (on the grounds of Mr. Donald G. Mitchell). It is about 120 feet above the sea-level—which indicates a sinking in the ice, after passing the

* The Mount Tom range of trap extends north from Meriden to Mt. Tom in Massachusetts. See map, Plate v, in volume xxiv, of this Journal, June, 1883.

West Rock ridge, of nearly 300 feet, or half the whole amount it experienced before it landed. Two other large bowlders lie near it. It is possible that these, and others of the bowlders, reached terra firma at the final melting, or through crevasses, in which case part of the sinking may have taken place abruptly.

The distribution of bowlders and till along the western border has been stated above to be somewhat moraine-like. But it is largely a consequence of the fact that these hill-slopes, 100 to 400 feet in height above the plain fronting them, faced obliquely the advancing ice, the trend of the border being north and south, and the flow of the ice S. 12°–35° W. Consequently, as above illustrated, the stones and earth that were not high enough in the glacier to pass the summit, were dragged out or dropped. There was also diminished movement and therefore long detention of the ice-conditions against the declivity, and this favored deposition.

c. Probable slope of the upper surface of the ice down the valley.—To understand the conditions at the south end of the great valley it is necessary here to consider the question as to the slope of the ice in the direction of the Connecticut valley on which the southward movement was more or less dependent.

Wells River (a little north of the latitude of the White Mountains), is distant from New Haven about 200 miles, and from the south shore of Long Island, the supposed southern limit of the glacier, 240 miles. The height of the ice-surface about the White Mountains above the sea-level, according to the best observations, including those by Professor C. H. Hitchcock, was at least 6,000 feet and probably 6,500 feet. Assuming the height to have been 6,000 feet and this level to have extended west-by-north (the probable direction of contour lines on the glacier) over the Wells River region, the slope of the ice along the 240 miles would have been about 0·17′, equal to $4\frac{3}{4}$ feet in 1,000, or 25 feet per mile. With the height 6,500 the slope would have been 5 feet in 1,000. Either angle of slope is very small. In the Alps the lowest mean-slopes are $2\frac{1}{2}°$ to 3°, or $4\frac{1}{2}$ to $5\frac{1}{4}$ feet per 100, a rate ten times greater than the above; but the thickness of the ice there is not over 500 feet. In Greenland, where the conditions were much like those of glaciated North America, the slope observed by Jensen over the Frederickshaab glacier* was 0·49′, or about 75 feet per mile; and that measured by Helland on the glacier in the vicinity of Jakobshavn, 0·26′, or about 45 feet per mile. 45 feet to the mile would make the height of the ice-surface at Wells River over 10,000 feet.†

From such facts it would appear to be a safe conclusion that

* Meddelelser om Grönland 1879, and this Journal, III, xxiii, 363, 1882.

† Even smaller angles of slope are stated to be sufficient to cause motion in

the height of the ice-surface above the sea-level at Wells River and the White Mountains was *at least* 6,000 feet. On this assumption, and supposing the slope of a line on the surface in the direction of the valley equable, and the height at the southern termination on Long Island, 100 feet, the height over the region of Windsor and Mt. Ascutney, in Vermont, would have been about 4,500 feet, and over the New Haven region very nearly 1,000 feet.

It is still a question whether the height of the ice-surface to the northward was due solely to the accumulation of ice and not partly to an increase in the southward slope of the land. Yet, since even an increase in elevation of 500 feet would make little difference in the result, it follows, if the above conclusion as to the amount of slope required for movement in the valley is admitted, that

(1) For *movement down the valley the ice should have had nearly or quite its maximum thickness;* that is, the maximum thickness of the great glacier over that region. Further, that

(2) *Its flow could not have continued after melting had far advanced;* and further, that

(3) *Movement in the valley over lower New England by local glaciers after the disappearance of the general glacier is improbable;* the supposed local glaciers (as the scratches likewise show) were merged in the one great glacier, *and acted locally only through its aid.* Supposing the great glacier to have melted away so as to have reduced the ice over the valley to just the limits of the Connecticut valley, which is nowhere over 1,500 feet deep and generally less than 1,000, it is not at all probable that with this slope (the mean for the valley 3·3 feet a mile, this Journal, xxiii, 190, 1882) the ice could have overcome the various resistances to motion.

2. *The fact of a southeastward movement in the upper ice of the Glacier.*

The evidence as to a southeastward movement in the upper ice is afforded by *glacier scratches outside* of the valley, and by *transported bowlders within it as well as outside.*

a. Glacial scratches over the high plateaus of western and northwestern Connecticut, 800 to 1,500 feet in elevation, have directions between S. 12° E. and S. 45° E.

Greenland, but better measurements and knowledge of conditions are needed before any confident conclusion can be drawn.

In my paper of 1873 (this Journal, III, v, 108), I assume a slope of at least 10 feet a mile, and this gave a height for the glacier of 13,000 feet in the region of the supposed icy plateau on the Canada water-shed. For a reason stated beyond, the surface along the line crossing the St. Lawrence valley may have been level, and the slope confined to the ice above and below it; and that above may have been only just enough to keep the St. Lawrence valley full to the required level.

According to my observations in Connecticut, the direction in eastern Huntington is S. 14°–25° E., and near Lane's Mine in Monroe, S. 12°–13° E., places within 12 miles of the New Haven region; in the towns of Norfolk, Preston and Kent, farther west, S. 18°–20° E.; of Warren, S. 30° E.; of Newtown, S. 32° E., and 2 miles farther west, S. 41° E.; of Sharon, S. 33°–36° E.; of Cornwall, S. 33°–36° E.; and on Mt. Washington and its highest summit, Mt. Everett, in southwestern Massachusetts (the latter, 2,634 feet high), S. 18°–29° E. The direction in Goshen, according to Mr. H. Norton is S. 23° E. and S. 38° E.; in Norfolk, according to Mather, S. 20°–25° E.; and on Mt. Tom, in southwestern Litchfield, according to E. Hitchcock, S. 17°–22° E. Other facts of similar import from eastern New York, Massachusetts, Vermont and New Hampshire, are given in my former paper. The following White Mountain observations, from the New Hampshire Report by Professor C. H. Hitchcock (vol. iii, pp. 177–195), are of later publication.

Mt. Adams, W. side, height 5,500 feet	S. 58° E.
Between Adams and Jefferson, near gap (4,939 ft.)	S. 33° E.
Top of Mt. Washington (6,293 ft.), smoothing and faint markings (at 5,800–6,000 feet, transported stones, p. 204), but striæ obscure	S. 43° E.
200 feet above Lake of the Clouds	S. 30° E.
Lake of the Clouds (5,000 ft.), the intersecting directions	S. 22° E. S. 52° E.
Between Mt. Pleasant and Mt. Franklin (4,400 ft.)	S. 30° E.
Between Mt. Pleasant and Mt. Clinton (4,050 ft.)	S. 30° E.
Near top of Mt. Clinton (4,320 ft.), N. side	S. 47°–52° E.
Mt. Clinton, S. peak	S. 50° E.
South end of Mt. Webster	S. 37° E.
Top of Mt. Webster (4,000 ft.)	S. 30° E.
Top of Mt. Moosilauke (4,811 ft.)	S. 22° E.

The abrasion observations thus far made appear to show that the *mean direction of glacier flow* in western Connecticut and Massachusetts was somewhere between S. 12° E. and S. 38° E., and probably between S. 12° E. and S. 25° E.

b. The evidence from bowlders outside of the Connecticut valley is of the same import.

Percival states that transportation over Litchfield was S.S.E., as indicated by the distribution of limestone blocks from Canaan—which means about S. 20°–25° E. A few of these Canaan limestone bowlders I have found lying now in Orange, within four miles of the New Haven region, indicating transportation for 48 to 50 miles in the direction S. 16° E. They are easily recognized by the tremolite and canaanite (massive white pyroxene) they contain. Bowlders of quartzyte, from the same region, or from Berkshire, just north, are widely distributed. Bowlders of porphyritic gneiss from the north-

west are very numerous over Orange and Woodbridge.* It is not necessary to multiply facts of this kind; for it is a matter of common observation over New England that the chief part of the drift came from the northwestward.

c. Bowlders within the area of the wide Connecticut valley prove that the southeastward movement or ice-stream extended over the valley. Those of the unmistakable porphyritic gneiss of the Naugatuck valley, which are scattered so widely over Woodbridge and Orange, occur also in the New Haven region; and one, now three miles east of the western limit of the region is over 20 cubic feet in size. Masses of ordinary gneiss, from the same general source, are numerous for two miles east of the western border, and among them are some of 100 cubic feet and larger; and smaller ones down to a foot in diameter are of occasional occurrence for a distance of at least twelve miles eastward. Quartzyte bowlders, derived, in all probability, from the Canaan or Berkshire region, are more numerous than those of gneiss, evidently because of their greater durability; they are scattered widely, and I have found some, probably from the same source, 15 miles northeast of the city of New Haven.

Similar facts have been observed through other parts of the Connecticut valley. Professor E. Hitchcock states, in his Massachusetts Report (1841, p. 381), that the bowlders of syenyte and granite from the west side of the Connecticut in Massachusetts are found in great numbers on the east slope of the Mt. Tom range, all the way from Mt. Tom to Hartford. To this I add that I have found a syenyte bowlder from the same source 10 miles south of Hartford, and 15 from the western limit of the old Connecticut valley. He says also (p. 605), that bowlders of quartz containing manganese and iron ores in peculiar concretionary forms, derived from Conway *west* of the valley, are abundant about Amherst, southeast of Conway near the *east* border of the valley, and Professor B. K. Emerson, of Amherst, informs me that they occur farther east in Pelham.

Up the valley to Windsor, Vermont, the same courses have been reported by Professor C. H. Hitchcock, who says, in his New Hampshire Report (iii, 263, 1878), that bowlders from Mt. Ascutney (which stands on the west border of the valley and has a height of 3,200 feet), are distributed southward along the valley to Bernardston, over 60 miles, *but also southeastward* across the valley; one, 20 feet long, 27 miles, was carried

* The crystals of feldspar in this porphyritic gneiss are generally 2 inches long and ¾ inch wide, making the rock easy to identify. It forms part of a band of gneiss to the westward of, and 10 to 20 miles from, New Haven, ranging in a N.N.W. direction from Bridgeport to Prospect, places bearing S. 45° W. and N. 12° W. from New Haven.

S. 10° E., into Surry; another 5 feet long, 35 miles, S. 8° E. into Keene; others, 42 miles, S. 20° E., to the west base of Monadnock; along with which large bowlders, occur many others of smaller size.

It is thus evident that a glacial movement in a direction crossing the valley south-southeastward is as well established as that in the direction of the valley. North of Windsor evidence of both movements occurs, as already stated; southeastward scratches are most common.

3. *Correlations of the two movements as to time and drift-depositions.*

a. The valley movement continued until the general glacier-flow in the region ceased. For the scratches in the direction of the valley are the last that were then made. They are not only scratches, but over the sandstone often deep ploughings; not of occasional occurrence, but universal, every fresh removal of soil from the rock bringing them to light, and showing in Connecticut, as far as observed, no marks of any later transverse movement.

b. The valley movement was cotemporaneous throughout with the general glacier-flow. This follows from the statement on page 349 as to the thickness of the ice and the angle of slope required for a valley movement. It is indeed a necessary consequence of the fact that thickening the ice over a valley to maximum thickness would increasingly facilitate the flow in its direction, notwithstanding any transverse motion in the general ice-mass; and a thinning that would finally leave it a local glacier would enfeeble its motion or stop it altogether.

Consequently valley-movements, with exceptions in a mountain region, were not those characterizing the beginning or end of the Glacial era, but the movements that prevailed through its height. The two went on together, an *upper* general flow over a *lower* valley flow.

c. But *it may be questioned whether the upper flow kept its course unchanged quite across the great valley of the Connecticut in the States of Massachusetts and Connecticut.*

A small narrow valley, especially if steep or gorge-like, would have no valley-flow of ice, owing to friction; and the glacier would readily pass it, impeded only, if at all, by the resistance from shearing. But where the valley was larger, and had its valley flow, the case is different; yet facts that have been collected prove that this resistance was overcome in multitudes of cases over the country. And it was so in the case of the Connecticut valley in Vermont and Massachusetts, the facts above cited as to transported bowlders about the region of Amherst and Massachusetts being evidence. About

Ascutney there appears to have been some southward deflection of the *upper* or *southeastward* stream by the valley flow, for the direction of transport across is in part only 8° east of south; yet the differences of direction observed (p. 351) may have been due to the height on Ascutney from which the bowlders were taken, whether within the range of the lower current, or near the limit of the two, or far above it. About Amherst the evidence from bowlders proves clearly that the upper ice-stream continued quite across the valley. In central and southern Connecticut, the valley has a breadth of 25 miles; and positive proof that the upper current continued across has not yet been found. The distribution of bowlders indicate a flow half way across, and probably farther; but whether the upper ice did not finally in the eastern half lose its own motion and take that of the lower for the remainder of the breadth of the lower stream is yet to be ascertained. Such an event could not have happened unless the valley-flow succeeded, by its rate of discharge, in taking the southeastward slope of the overlying ice out of it, so that the only surface slope along this portion was in the direction of the valley; and were this done, the valley movement would have necessarily become the only one. Even if this were a fact, the slope of the ice-surface *east* of the eastern border of the Connecticut trough would have been southeastward, and so also the course of movement.

d. Great deflections in the courses of the transported bowlders within the valley took place on account of their sinking from the upper or general current into the lower or valley stream. In this way, as happens in the ocean, the lower current became the transporter and distributer of material derived from the upper. It was supplied with stones from the *north*westward and carried them *south*westward.

This fact is abundantly and strikingly illustrated in the distribution of the bowlders of gneiss. In the New Haven region they are far the most numerous, and of largest size, along the *eastern* slope of the West Rock ridge. The map shows that this ridge curves eastward at its southern extremity, making thereby a large deep corral of sickle-like outline facing almost directly the valley ice-movement, whose direction there was S. 16°–26° W. These bowlders of gneiss are most abundant over this portion of the declivity, south of Wintergreen Lake. A few hundred yards south of the lake, one of the bowlders, now in three pieces, has a length of 12 feet.

These bowlders, derived from the high land of northwestern Connecticut, must, beyond question, have passed the summit of the West Rock ridge—where between 400 and 650 feet in height—while in the upper stream of the glacier; for in no other way could they have got to the *east* side of the ridge;

and it is also beyond question that they finally got into the valley current, and were drifted back into the well-arranged corral. Some are now on the summit of the ridge; one of several cubic feet is near the "Judges' Cave;" but the larger part are a third way down the eastern slope and below this level. The gneiss bowlders are mingled with those of trap and sandstone; and nothing shows difference in time of deposition.

This kind of evidence is repeated again along the Mt. Tom ridge. Professor E. Hitchcock states in his Massachusetts Geological Report (p. 381) that bowlders of syenyte and granite, taken from the syenyte band west of the Connecticut in that State, are found in great numbers on the *east* slope of the Mt. Tom range *all the way from Mt. Tom to Hartford* Eight miles farther south, in the village of New Britain (as made known by Mr. James Shepard of that place), a bowlder of zoisite and radiated hornblende (chiefly the former), measuring about 2×2×3 feet, was turned out in grading, which must have come from a locality *west* of the Connecticut valley, in Goshen, Williamsburg or Conway, Mass., Professor Emerson informing me that this region affords just such a zoisite rock, and especially "the first row of high hills as you go up from the Connecticut valley." (Letter of June 16, 1883.) Still farther south (20 miles S. of Hartford) and just *east of a more eastern* trap ridge (6 miles farther east), extending from south of Hartford to Saltonstall Lake, I found, near the Air-Line Railroad, a syenyte bowlder 10 cubic feet in contents, which came from the syenyte band of Hatfield and Whately, Mass. (Emerson), west of the valley;* and near it lies another twice larger, of similar general aspect, but not so certainly identifiable.

Such facts prove that the phenomenon, although so remarkable, was general along the valley. They are instructive also with reference to the distance eastward to which the upper ice-stream extended over the southern part of the Connecticut valley region, though leaving the limit doubtful. They are good evidence that the two currents were moving at the same time.

4. *The direction over Long Island Sound.*

For twenty miles to the eastward and westward of New Haven bay the Sound has a mean width of 16 miles. Yet the greatest depth opposite New Haven bay is at present only 140 feet. Adding the height of the adjoining hills on its sides, the southern side of the trough has a height of 300 to 400 feet and the northern, of more than twice this amount.

*I submitted a fragment of the bowlder to Professor Emerson, of Amherst, and he writes that it is from the "syenite" band of Hatfield and Whately (Hitchcock's geological map), it agreeing precisely with it, containing much triclinic feldspar and small square crystals of orthite."

Since the Connecticut valley trough is not continued over the bottom of Long Island Sound, or through Long Island, the valley ice, as it moved out over the area of the Sound, left behind it those confining limits which had determined its southward course; and it is a question of interest whether it found new confining limits, or not, in the sides of the Sound trough.

The trend of the Sound is N. 75° E. Now this trend is transverse to the course of the *upper* or southeastward ice-stream of the glacier, the direction of this current having been, as above shown, S. 15°–25° E.

The mean direction was between these limits quite to the borders of the Sound; for on the Sound, 8 miles east of New Haven, near Stoney Creek, glacial scratches, covering large surfaces of gneiss and granite, have the direction S. 20° to 24° E.; others, 10 to 12 miles west of New Haven, in Stratford (near the N. Y. & N. H. railroad), S. 21° to 32° E.; and 18 miles west, near Bridgeport, S. 13° to 17° E.

Further, the bowlders of Long Island show that this was approximately the direction of flow over the Sound. Trap and sandstone bowlders were carried in great quantities from Connecticut to the island, and the most abundant deposits are situated on the parts lying S. 10°–20° E. from the New Haven region where alone the Triassic borders the Sound. On the north shore of the island, between Baiting Hollow and Northville, a region bearing S. 10° E. from New Haven, the bowlders of trap are very numerous; and the sandstone fragments at one place on the shore hills are in so great quantities that they seemed at first to indicate the existence near by of an outcrop of the Triassic.

Mather mentions the same fact in his New York Geological Report, remarking, on page 170, that from Roanoke Point for three or four miles east (points between Baiting Hollow and Northville) "a large proportion of the bowlders and pebbles are of red sandstone and trap rocks, like those of New Haven and that vicinity. In some places these rocks form one-third of the mass of bowlders, blocks and pebbles." He also states (p. 171) that a mile west of Wading River (4 miles west of Baiting Hollow) "a block of fine-grained limestone containing serpentine was found; it was precisely similar to the New Haven verd antique marble." It was probably from the Milford verd antique quarry, six miles southwest of the New Haven quarry, where the rock is more largely limestone than at the latter; in which case the mean direction of travel was S. 25° E.; if from the New Haven quarry, it was S. 13° E.

On one of the hills in the interior of the island, southwest of Riverhead, near Osborn or Bald Hill, bearing S. 15° E. from

New Haven, lie several large bowlders of trap, and one of red sandstone, along with others of gneiss. One of the trap bowlders contains over 200 cubic feet. Farther east, trap and sandstone bowlders are in rapidly decreasing numbers; and the same is true of the region to the westward.*

If then, as we have shown, the flow of the mass of the great glacier was at right angles to the Sound valley, it would have tended to move the ice of the Sound against and over Long Island, and not at all in the direction of the Sound, N. 75° E. To have had an eastward movement in the direction of the Sound the surface of the Sound-ice should have had a rising slope westward, and this is opposed by the facts already stated.† It is certain, therefore, that the view that the Sound valley was excavated by the glacier is not tenable. Further, the *lower* ice-stream, or that of the Connecticut valley, struck the ice of the Sound in the direction S. 13°–25° W., which would have helped a westward flow rather than an eastward.

All the facts thus point to the conclusion that the great glacier passed, with essentialy unchanged course as far as the upper ice is concerned, from Connecticut across the Sound and the island beyond. At the same time, the existence, though sparingly, of small masses of trap on Long Island for a few miles west of the meridian of New Haven, appears to show that this valley-stream moved south-southwestward not only over the towns next west of the New Haven region but at times also nearly across the Sound before losing wholly its own direction.

5. *Effects probably consequent on the change of course in the lower, or valley, ice-current manifested in the drift depositions.*

The following are the principal facts as to the deposition of the till:

(1) The till of the New Haven region is most abundant along the eastern declivity of the western border, east of the

* Trap bowlders occur sparingly on the eastern part of Long Island, and a few reached even Block Island. Sandstone fragments have the same range but are far fewer, because less durable. Block Island is nearly east of New Haven, but S. 20° E. from the Triassic of central Massachusetts. To the westward, some bowlders of trap are found about Port Jefferson, and rarely sandstone fragments. One chloritic bowlder, probably from two to ten miles west of New Haven, lying on the shore, measured 25 × 20 × 15 feet. Port Jefferson is south of southeastern Milford (Connecticut), and as Milford and other towns north of it, on the western border of the Triassic region, received numerous bowlders of the kind by the lower glacier current, the transportation to points so far west on Long Island is not surprising. (*Western* Long Island received its trap and sandstone bowlders, as was long since announced, from New Jersey and southern New York.)

† The movement of the great glacier, over southern Connecticut, in a direction *at right angles* to the Sound-ice implies that there was an equable slope in the surface of the glacier toward the Sound, and hence that the ice-surface over the Sound was nearly uniform from west to east, although the eastern end is half a degree farther north than the western.

Maltby Park valley (the central north-and-south depression of this border), where the depth is generally from 10 to 20 feet.

(2) The Maltby Park valley has, in general, little till over it, the surface being largely one of bare ledges and intervening marshy areas.

(3) But at one place in the eastern half of this valley (*Rd*, on the map, p. 342) *the till has a depth of more than* 107 *feet; and this piling up of till made there the isolated Round Hill* (as it is called), and gave it a height of 304 feet above mean tide, while the hills of the western border just east and southeast are only 140 to 200 feet high. Moreover these hills, and the surface along the road south of Round Hill, have not enough till to conceal the jagged rocks.

(4) The broadly rounded hills of southern Orange within three miles of the Sound, 200 to 280 feet in height, are deeply covered with till—the depth in some parts 40 feet or more.* Farther from the Sound, the till is usually of less depth, and rock-exposures are not uncommon.

The unusual amount of till and bowlders against the eastern declivity of the western border has already received explanation (p. 348).

The existence of bare ledges and little till over the Maltby Park valley is evidently a consequence of denudation; the region was swept by deep waters from the melting glacier—part going southward, directly to the Sound, with a pitch of 30 feet a mile for the four miles, and the rest northward into the valley of West River north of Westville.

The third feature mentioned is of less obvious explanation. Round Hill stands prominently in view from all directions. This isolated feature, its form, and the height of the surrounding region are shown on the following map. The great depth of the till at the summit had seemed probable from the fact that, unlike the other hills, it has no outcropping rocks over the upper third of its height; but it was *proved* by an excavation for a well made under the orders of Mr. R. M. Burwell, the owner of the place. The well was carried down 107 feet through the firmest of stoney and somewhat clayey till before water was obtained, and even at that point rock had not been reached. The highest outcrop of rock on the sides of Round Hill is at 174 feet above mean tide.

Another remarkable feature of the region is a deep trench on the southeast and east sides of the hill, only 118 to 130 feet above sea-level, something like the trench around a fortified acropolis.

* On Shingle Hill, a little to the southwest of the region included in the map, an excavation for a well passed through 40 feet of till; on other hills, several wells go down 20 to 35 feet.

Round Hill is elongated northward—N. 8° W.; and half a mile off in that direction the height is 210 feet, and the depth

Map of Round Hill and vicinity, on the western border of the New Haven region.

of till is at least 21 feet, as found in a well-digging. It is also lengthened in the direction S. 10° W.; and only here is the slope an even one—a fact represented in the map above.* The hill thus covers and fills the eastern half of this part of the Maltby Park valley. At its western foot flows Cove River, the stream of the valley. Across this stream, another rise immediately begins, that of one of the deeply till-covered hills of southern Orange; so that the Maltby Park valley is here filled

* It has the constitution, as the description shows, of the "lenticular hills" of Professor Edward Hitchcock. But the quality *lenticular* is not an essential feature of such till-made hills, though common, as it is, and for a like reason, of many of the rocky ledges of the same region.

also over its western half, and consequently its breadth in this part is reduced to about 40 yards—although three-fourths of a mile wide just north. It is evident from the features of the region, moreover, that the depositions of till to the westward are essentially a continuation of those of Round Hill; that the valley was here to a considerable extent obstructed by the depositions; and that part of the flood waters from the melting glacier, besides making a lake above, flowed westward and joined the river-course next west, that of Indian River, the extensive flat meadows of Cove River north of the obstruction being elongated in that direction.

With reference to the origin of Round Hill, we note that the direction in which it is elongated is most nearly that of the *lower*, or valley, ice-current; and if we regard the more southwestern depositions as its continuation, the direction becomes S. 10°–15° west, which is yet nearer the course of that current, though still differing by 15 to 20 degrees. The actual direction of the ice-movement around it is registered at many places in glacial scratches. The courses are indicated on the map by arrows. They average S. 33° W. to the south and southeast of the hill, while to the north, the directions S. 45°–56° W. occur.

It is plain, from these facts, that the making of the solitary hill cannot be accounted for on the supposition of an eddy in the flow of the ice. The uniformity in the course of the scratches shows that there was no eddying.

The position upon the western border, where there were large drift depositions, and must have been, as already suggested (p. 348), the frequent opening of crevasses, may have had something to do with its formation. But no *line* of crevasses would have made so local a deposit.

Another point with regard to its position is its nearnesss to the Sound—the distance about three miles; and in this fact and the preceding, in connection with the character of the ice-movement, we have apparently the only data for an explanation. Over the Sound and its borders, the lower or valley ice-stream became warped around into the course of the general glacier-mass. This forced bending must have produced its greatest crevassing effects over the southwestern part of the valley region, within the plane of contact between the upper glacier stream and the lower—a plane that rose from the surface of the Sound at a small angle; and these effects would have been at a maximum in the part of the glacier where this plane intersected the north-and-south crevassed course of the western border. The existence is therefore probable of a knot of profound crevasses on this border region, at some point of greatest pressure, not far from the Sound; and, if a fact, a stream of water, or river, from the upper surface of the glacier

may have here plunged down—like some rivers in glacial Greenland—causing a local deposition of the stones and earth that were in the ice, and thus have located and formed the till-made hill.

If the change of course were due only to the slope of the upper surface of the ice *at the place* it might have gone forward quietly. But if partly due to pressure from the northward along the valley there would have been the resistance and wrenching supposed.

The plunging waters would account also for the size and position of the half-encircling valley, cut in the schists about Round Hill; for this valley's being mostly free from drift; and for the trench which is its continuation eastward to the New Haven plain; for this was the way of discharge of the descending waters.

But the stream of water descending a crevasse could deposit only the drift encountered in its course on and through the ice; and wherefore then so high a pile in Round Hill? And why were 19-20ths of the drift in the hill the contributions of the valley or lower glacier current?

The height is evidence of long-continued deposition.

The valley source of the material proves that the drift of the glacier was mostly confined to the lower ice.

The mixture along with the trap and sandstone of some porphyritic gneiss, quartzyte, etc., from the northwestward, and the increased amount of the same in the western part of the hill, shows that the upper ice-stream was supplying material at the same time with the lower, though in much smaller amount.

The height of the hill, in connection with the nature of the material, indicates, further, that the lower, or valley, ice-stream had a depth in that region of at least 300 feet.

Round Hill is an example of a "kame." It is probable that the Andover kames were located by *crevasses* in the glacier that overlaid the region when the material was deposited.

Other facts bearing possibly on the origin of Round Hill will be presented in the following part of this paper—On the Terrace (or Champlain) formation of the New Haven region, its deserted valleys and its "kettle-holes."

Conclusions deduced in the preceding pages.

1. Two movements existed in the glacier-ice—a lower along the valley, an upper crossing it obliquely.

2. The two movements were simultaneous.

3. The upper ice kept its motion over the southward-flowing valley-ice quite across the Connecticut valley in Massachusetts, and across ten miles at least of its breadth in the southern half of Connecticut.

4. The lower or valley ice-stream was most rapid when the general glacier was of maximum thickness.

5. The glacial flow probably ceased when the melting was half completed, except in the mountain regions and some special localities elsewhere of limited extent; in which case, the disappearance of the general glacier did not end in leaving one or more long local glaciers in the lower half of the Connecticut valley.

6. Both the upper and lower ice-streams transported drift-material. The material from the upper that sunk into the lower stream was carried by it south-southwestward and deposited with the drift of the latter, and often against the eastward slopes of obstructing ridges.

7. The lower ice-stream lost its own direction of flow on reaching Long Island Sound, and took that of the general glacier mass across the Sound and Long Island.

8. The obstruction to flow in the western border of the New Haven region was the cause of crevasses and much drift deposition; and between this action and the warping around of the valley ice near and over the Sound, causing intersecting crevasses, the high local till-deposit of Round Hill was produced.

ART. XL.—*On a variety of Descloizite from Mexico;* by SAMUEL L. PENFIELD.

DURING the spring of 1883 Professor Wolcott Gibbs of Cambridge sent some specimens of a vanadium mineral to Professor George J. Brush for identification. The specimens seemed to be fragments of a coating from one-eighth to three-eighths of an inch in thickness, composed of groups of prismatic crystals arranged somewhat like the common crystallizations of prehnite or calamine. On the top surface of one specimen minute crystal faces were visible, very irregularly grouped together and curved, but in the other cases it simply appeared rough and somewhat weathered. The structure on the cross fracture was columnar-fibrous, sometimes radiated; it showed at all times a fresh and homogeneous interior of a dark brown color and resinous luster very much resembling some varieties of sphalerite. Cleavage distinct, parallel to the columnar structure. Hardness 3·5; specific gravity 6·200–6·205.

Before the blowpipe it gave reactions for vanadium, arsenic, lead, copper and zinc. Heated in the closed tube it fused very readily, boiled up violently, and gave off water which reacted neutral to test paper.

The specimens were said to be from near Zacatecas, Mexico,

and were sent to Dr. Gibbs by Herbert G. Torrey, Esq., of the U. S. Assay office in New York. In all physical properties the mineral seemed identical with *tritochorite* recently described by A. Frenzel* from an unknown locality in either Mexico or South America. Whether identical with Frenzel's mineral or not it was regarded as worthy of further investigation and Professor Gibbs kindly provided me with the material for analysis.

Various methods of analysis were tried but the following was found to be the most satisfactory. The mineral was readily soluble in warm dilute nitric acid; to this solution enough sulphuric acid was added to combine with the bases and the whole was evaporated till nitric acid was completely expelled; after cooling, cold water was added and after standing for some time the lead sulphate was filtered off and weighed with the usual precautions. The lead sulphate was soluble in ammonium acetate, except a slight residue of silica and a trace of vanadium, both of which were taken into account. No trace of vanadium went into solution in the ammonium acetate, so that the separation was almost complete. To the filtrate from the lead sulphate hydrochloric acid and sulphurous acid water were added and allowed to stand. The sulphurous acid was subsequently expelled by boiling and copper and arsenic precipitated by means of hydrogen sulphide, filtered off and washed. After drying the sulphides of copper and arsenic they were transferred to a dry beaker and dissolved in nitric acid. The filter paper was treated in another glass with nitric acid and potassium chlorate to destroy organic matter. The solutions were then evaporated to dryness on a water bath, the residue dissolved in water and the arsenic acid precipitated by means of magnesia mixture as ammonium magnesium arsenate. This was collected on an asbestos filter and weighed first after drying at 110° C., and then again after ignition, as pyrophosphate. The copper was precipitated from the filtrate from the ammonium magnesium arsenate by means of hydrogen sulphide and weighed, after ignition in hydrogen, as subsulphide. The filtrate from the first arsenic and copper precipitate was evaporated to dryness on the water bath and finally ignited to expel as much of the sulphuric acid as possible. The residue was moistened with strong nitric acid to oxidize the vanadium and evaporated to dryness on the water bath. The residue treated with water and ammonia gave a solution in which there was a flocculent yellow precipitate of zinc vanadate; by adding acetic acid to acid reaction this precipitate dissolved, leaving only a slight precipitate of vanadate and phosphate of iron; this latter was filtered off, washed, ignited, moistened with nitric acid and again ignited and weighed. It was then fused with sodium

* Tschermak's Min. und Petr. Mittheilungen, iii, 506; iv, 97.

carbonate, the fusion soaked out in water and the oxide of iron thus separated and weighed. The soluble part of the fusion contained both vanadic and phosphoric acids. To the dilute acetic acid solution containing the vanadium and zinc, lead acetate was added which precipitated all the vanadium as a basic lead vanadate. This precipitate was washed with hot water and dried; it was then transferred to a beaker, the paper burned and the ash added; the whole was then dissolved in nitric acid, sulphuric acid added to precipitate the lead and evaporated till nitric acid was expelled. The vanadic acid was then dissolved in water, filtered from the insoluble lead sulphate, evaporated in a weighed platinum dish and after expelling the sulphuric acid and strong ignition, weighed as pentoxide. As regards the purity of the vanadium pentoxide obtained by the above method the following can be said. It was completely soluble in aqueous ammonia and the solution when transferred to a weighed platinum crucible and evaporated and ignited gave results agreeing with the weight obtained by weighing in an open platinum dish. The pentoxide was reduced to the trioxide by igniting in a current of hydrogen gas and gave in two cases a loss of oxygen equal to 16·86 and 16·98 per cent of the pentoxide employed. Vanadium pentoxide with molecular weight 192·4 should give by reduction to the trioxide a loss of oxygen equivalent to 17·54 per cent.

The zinc which remained in the filtrate from the basic lead vanadate was precipitated, along with the excess of lead used as a precipitant, from the acetic acid solution by means of hydrogen sulphide. The sulphides after settling were collected on a filter, washed and dried; they were then transferred to a dry beaker, the filter paper burned and the ash added; to this strong nitric acid was added with enough sulphuric acid to combine with the bases, and the whole evaporated till sulphuric acid fumes began to be given off. After cooling and addition of water the soluble zinc sulphate was separated from the lead sulphate by filtration. The zinc was then precipitated as basic zinc carbonate by means of sodium carbonate with the usual precautions, washed and weighed as oxide. The zinc oxide was in all cases tested and found to be free from vanadium.

Phosphoric acid was determined in a separate portion by means of ammonium molybdate. The first precipitate seemed to be impure; it was therefore dissolved and reprecipitated with ammonium molybdate before its solution in ammonia and precipitation with magnesia mixture.

Water was obtained by igniting a weighed portion of the mineral to low redness and calculated from the loss of weight. To guard against any inaccuracy another determination, analysis III was made by igniting in a Bohemian glass tube and col-

lecting and weighing the water in a chloride of calcium tube. The air-dry mineral did not lose weight by heating to 100° C., and lost only 0·12 per cent by heating for two hours at about 360° C.

The results of the analyses are as follows:

	I.	II.	III.	Mean.	Ratio.	
V_2O_5	19·00	18·90	---	18·95	·104	·121
As_2O_5	----	3·85	3·78	3·82	·016	
P_2O_5	·18	----	----	·18	·001	
PbO	54·99	54·91	54·89	54·93	·247	·484
CuO	6·76	6·79	6·68	6·74	·085	
ZnO	12·14	12·34	12·23	12·24	·151	
FeO	----	·06	·06	·06	·001	
H_2O	2·73	2·65	2·72	2·70	·150	
SiO_2	·12	....	----	·12		
				99·74		

The ratio of the pentoxide to the protoxide to water = ·121 : ·484 : ·150 = 1 : 4·00 : 1·24 = 4 : 16 : 5. If we assume the ratio to be 1 : 4 : 1 we obtain the formula $R_3(VO_4)_2$, $R(OH)_2$ or $R_2(OH)VO_4$ which is now regarded as the true formula for descloizite. It does not seem probable that the ratio 4 : 16 : 5 giving a complicated formula, is correct. The excess of water is, however, not due to the presence of hygroscopic water, and especial care was taken, as explained above in the description of the method, to obtain an accurate and sharp determination.

Unfortunately our knowledge of descloizite is somewhat uncertain, but it probably has the formula $R_2(OH)VO_4$ or $R<^{OH}_{O}>V=O$, and with our present knowledge I prefer to refer the vanadate, which has been analyzed, to this species, it differing only in having a part of the vanadic acid replaced by arsenic acid.

As to the purity of the material which was analyzed, I will state that the specimens were apparently homogeneous, and two thin sections which were prepared revealed no impurity when examined with the microscope.

In regard to the relation between this mineral and Frenzel's tritochorite, little can be said. He states that his mineral, although from an unknown locality, is from either Mexico or South America, whence it was brought to England or France for the manufacture of vanadium compounds. His description of the mode of occurrence and physical properties is almost identical with the specimen in my possession. The minerals have the same density and are alike in many particulars as seen by the following comparison of the analyses.

	V_2O_5	As_2O_5	P_2O_5	PbO	CuO	ZnO	H_2O	
Tritochorite, Frenzel G.,	6·25	24·41	3·76	....	53·90	7·04	11·06	.... = 100·17
Descloizite, Penfield,	6·205	18·95	3·82	0·18	54·93	6·74	12·24	2·70

It does not seem probable that 2·70 per cent of water could have been overlooked in the analysis of tritochorite and the difference in the percentage of vanadic acid in the two minerals is also quite large. Nevertheless, the minerals are so much alike in all physical characters, that it may be possible that they are identical. But more definite facts in relation to the occurrence of the minerals and further analyses are necessary in order to decide definitely the relation between them.

Sheffield Scientific School, June 23d, 1883.

Art. XLI.—*On Hybocrinus, Hoplocrinus and Bærocrinus;* by Charles Wachsmuth and Frank Springer.

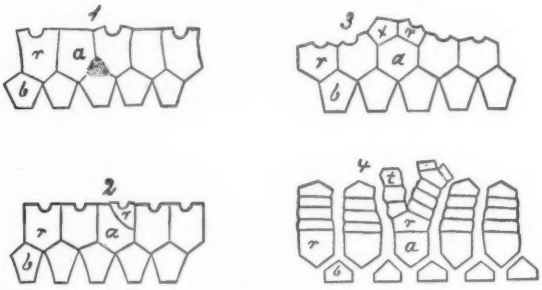
When we prepared the generic description of *Hybocrinus* for the first part of our Revision of the Palæocrinoidea, we were not aware that the Duke of Leuchtenberg had described a species from Russia under the name of *Apiocrinus dipentas*, which had been referred by several writers to the former genus. Our first knowledge of the occurrence of this genus in Russia was derived from Professor Zittel's Handbuch der Palæontologie, received while our work was in press, in which Zittel placed *Hoplocrinus* Grewingk, *Homocrinus* Eichwald (not Hall), and *Bærocrinus* Volborth, as synonyms under *Hybocrinus* Billings. Unable at that time to obtain the necessary literature and over-anxious to have the generic records as complete as possible we copied Zittel's synonymic list, quoting him as authority, and left the recording of the species, of which we knew nothing, for some future time. That we gave simply a quotation from Zittel was overlooked by P. Herbert Carpenter in his late paper "On the Relation of *Hybocrinus*, *Bærocrinus* and *Hybocytites*," published in the Quart. Journ. Geol. Soc., London, August, 1882, page 292. Carpenter found it "rather curious" that we had not observed the differences existing among the azygous plates of the Russian and Canadian species, and while quoting *Hoplocrinus* and *Bærocrinus* as synonyms of *Hybocrinus*, had not noted the species described under those genera.

We have since had opportunity to examine the numerous publications which have appeared on these genera and have come to the conclusion that both Russian forms should be separated from *Hybocrinus* even more than subgenerically.

The genus *Hybocrinus*, as originally defined by Billings, is

composed of five basals (no under basals), five radials and two azygous plates. Four of the radials are equal and alternating with the basals; the fifth much smaller and resting upon the right sloping side of a large azygous plate which stands in line with, and has about the size of the four large radials. The left sloping side of the azygous plate is occupied by a second azygous piece, which in form, size and position closely resembles the fifth radial lying adjacent to it on the right. There are only five arms, undivided, and apparently devoid of pinnules.

The Russian form (fig. 2), is very similar to the American. It has the same humped appearance; also five simple arms, and the plates in the calyx are similarly arranged, but contrary to the American it has only a single azygous plate. The left side of this plate extends to the upper margins of the four large radials, while its sloping right side supports the fifth radial, which is much smaller and triangular, and taken together with the azygous piece as one plate the two resemble in form the four large radials, only that there is an arm facet and this



1, *Bærocrinus;* 2, *Hoplocrinus;* 3, *Hybocrinus;* 4, *Iocrinus.*
b, basals; *r*, radials; *a*, azygous plate; *x*, special anal plate; *t*, plates of the tube.

pushed to one side. The Russian form, which is represented by Leuchtenberg's *Apiocrinus dipentas*, was, curiously enough, regarded by Eichwald (Lethaea Rossica, Band I, pp. 582–584), as identical with *Homocrinus* Hall, a genus with well-developed under-basals, to which he referred the species.

Under *Homocrinus dipentas*, Eichwald figures two specimens, the one Leuchtenberg's type from the Vaginatenkalk of Pulkowa, near St. Petersburg, the other from the Brandschiefer of Erras. The two specimens, which in their external appearance differ considerably, were afterwards referred by some authors even to the same species, while others have described them under distinct genera. The Erras specimen, which was referred by Volborth (Bulletin St. Petersb. Acad., vol. viii, 1865, p. 178), to a new genus, is known as *Bærocri-*

nus Ungerni; that from Pulkowa was placed by the same author under *Hybocrinus* Billings. The differences which exist between the latter form and the Canadian types of that genus were not observed by Volborth, but they were pointed out by Grewingk (Archiv. für die Naturkunde, Liv. Ehst. and Kurland's Ser. 1), vol. iv, p. 110, who placed only the Canadian species under *Hybocrinus*, and proposed for the typical Russian form the genus *Hoplocrinus*, accepting *Bærocrinus* for the Erras specimen. Eichwald, in reply, vigorously defended his first opinion, maintaining that the Erras specimen represented a monstrosity, that it was specifically identical with the Pulkowa specimen, and that both belonged to *Homocrinus* (Bulletin de la Soc. Imp. des Nat. de Moscow, ii, p. 150). Volborth responded (Ibid, p. 442), insisting that a species composed of two rings of plates could not belong to a species having three; that the Pulkowa specimen was a *Hybocrinus*, and that the Erras specimen was specifically and generically distinct therefrom.

Schmidt, who wrote several years later (Memoires de l'Acad. Imp. des Sci. de St. Petersb. (Sec. 5) vol. xxi, No. 11), acknowledged the differences between the Canadian and Russian species, but he regarded them as not of sufficient importance for generic separation. He took the Erras specimen to be an abnormal, imperfectly formed example of *Hybocrinus dipentas.*

Carpenter (Quart. Journ. Geol. Soc. London, August, 1882), agreed with Schmidt and Volborth that *Apiocrinus dipentas* was a *Hybocrinus* but only the typical form. He considered the simple azygous plate in the Russian species as "probably equivalent to the two present in the Canadian species," and he proposed a modification of Billings' generic definition, so as to include the Russian form; but he considered *Bærocrinus*, as defined by Grewingk, to be "an altogether different generic type."

The differences in the number and arrangement of the plates at the azygous side have been very generally regarded as excellent characters for distinguishing genera among Palæocrinoidea, and in the Cyathocrinidæ, which show but little variation in the general construction of the body, they frequently constitute, when the arms are unknown, the only means of separation. That in the present instance the two types happen to resemble each other in their umbonate form, can be no valid reason for making these genera an exception to the general rule, since all Cyathocrinidæ are more or less protuberant along the anal regions.

It has been satisfactorily proved that there exists a structural difference in the azygous plates of the respective types;

Volborth has established a genus for the Russian form and this cannot be disregarded without great inconsistency. That the one azygous plate in the Russian species is probably equivalent to the two in the Canadian, which we do not dispute, does not in our opinion alter the case. We have already shown (Revision I, pp. 65–75), that the differences among the plates of the azygous side in some of these genera are the result of modifications from one to another, and we hope to prove further on that the plates which constitute the azygous side, both special anal plates and adjoining radial, had a common origin in all these genera, and were gradually evolved from a simple azygous plate.

There is, however, another good distinction between *Hybocrinus* and *Hoplocrinus*, to which, as yet, little attention has been paid, although it has been indicated by Wetherby (Cincin. Journ. Nat. Hist., July, 1880), when he described the upper azygous plate "as rounded and crenulated at its distal extremity." Wetherby had discovered in Mercer county, Ky., associated with *Hybocystites problematicus*, in a siliceous limestone at the upper part of the Trenton group, several well-preserved specimens of *Hybocrinus tumidus* Billings, which he illustrated by several figures. Fig. 2 on Plate V, represents the azygous side of a specimen "showing the crenulated and convex upper face of the azygous plate," a structure which had not been found in any of the Russian specimens, and which they probably did not possess, if reliance can be placed upon the figures.

Wetherby states that in *Hybocrinus* "the form of the (azygous) plate is sufficient evidence, that it supports a strong ventral sac," and he says further, that "the crenulated condition of the articulating upper surface of this plate indicates the place of the lower exterior opening into this sac."

We are sorry that we cannot agree with Wetherby in some of his conclusions. We think the form of the azygous plate, on the contrary, indicates that the species had an unusually short ventral sac, or actually no sac at all, but was provided with a bulbous protuberance, in connection with—and forming a part of—the azygous (anal) plate. The structure is not well shown in the figure, and probably none of the specimens which had been discovered up to the time he wrote, exhibited satisfactorily the crenulated portions which form the upper part of the protuberance. We have, however, been favored lately with several excellent specimens, which Professor Wetherby has since obtained from the same locality, and these have afforded us somewhat better information respecting these parts.

The second azygous plate, up to the place where the crenulation begins, is irregularly quadrangular, the upper side

rounded and convex. The "crenulated part," which is much more delicate, and rarely preserved in the fossils, at first takes an upward direction, but soon bends abruptly inward, then downward toward the ventral cavity. The part comprising the latter side is not well shown in any of the specimens, but so far as we can judge, it seems that the crenulation does not extend beyond the upper edge. There is seen, however, in one of our specimens at that side a small projection, with possibly an opening, which may represent the anal aperture. The crenulated portion of the plate is continuous with the smooth part, there being no suture between them, but the division is marked by a well-defined curved ridge across the plate, which extends down a little lower next to the small radial, than at the opposite side. From this ridge pass out, nearly at right angles, numerous parallel grooves, which take an upward and inward course, and extend to the upper end of the plate. The grooves are so regular and deep, that they are evidently no mere surface ornamentation, but represent a complicated organic structure. The protuberance extends somewhat beyond the limits of the radial plates; it is compressed, being wider than deep, and its general appearance that of the rhombs in the Cystidea. Indeed the resemblance to the latter is so striking that we think the grooves of *Hybocrinus* communicated, like those of the rhombs, with the inner body.

From Wetherby's description we infer that he supposed the hollow portion of the anal piece to be solid, for he took the upper side of the crenulation to be "the articulating surface" of the plate, and heavy-plated, when in fact it is delicate and hollow within. Thus only can we explain his supposition that the azygous plate was supported by a strong ventral sac. He evidently thought the so-called "articulating surface" had been surmounted by other plates, and that these had formed the sac. In using the term "articulating surface," Wetherby probably did not think of a connection of muscles and fossæ, as supposed by Carpenter (Quart. Journ., 1882, p. 305), nor of any other movable mode of articulation; he simply meant the line of junction by suture. The word "articulation" has been frequently used in the description of Crinoids in the latter sense, and we have ourselves used it so; but it is not a good practice, and should be abandoned. A connection by suture ought to be called so, and the above term be used only when there is a movable connection or true articulation.

We suggested (Revision I, pp. 66 and 74), that in *Hybocrinus* the small radial corresponded to the upper half of the compound plate in *Dendrocrinus*, and that the lower half was probably represented in a portion of the large undivided azygous plate. We further alluded to *Homocrinus* as differing

from *Dendrocrinus* only, in having the suture between the sections of the compound plate sloping instead of horizontal, and that thereby the plate which in the latter had been a radial in position, had become, by slight modifications, transformed into an anal plate. These views were accepted by Carpenter, who expresses himself as entirely concurring with us respecting the mutual relations of *Hybocrinus*, *Homocrinus* and *Dendrocrinus*, but who suggests that probably the lower part of the compound radial of the latter genus was represented by the whole of the large azygous plate of *Hybocrinus*, and not by a portion of it, and in this he is undoubtedly correct. He disagrees with us, however, in regard to the relations of these genera to *Iocrinus*.

We described *Iocrinus* (Revision I, p. 68) as being composed of five basals, and five equal radials; the latter supporting three or four brachials, of which the proximal one of the right postero-lateral ray was bifurcating, toward the right supporting four brachials, and toward the left giving off a large ventral tube. We stated that the bifurcating plate, which to us appeared to be movable like the succeeding pieces, had a strictly radial position, but that it supported not only arms, but also the ventral sac, and that this plate, resting upon what we considered to be a true radial, was a brachial with interradial functions. We admit that the large so-called postero-lateral radial (fig. 4*a*) is not articulated to the bifurcating plates but united with it by suture; we insist, however, that the latter cannot be an azygous plate, as suggested by Carpenter,—nor is it a brachial—but that it is the equivalent of the combined small radial, and small anal plate in *Hybocrinus*, and that the large plate underneath (fig. 4*a*), which both Carpenter and ourselves took to be a radial, is an azygous plate, analogous to the large azygous plate in *Hybocrinus*. The change which we propose in the generic formula of *Iocrinus* will be better understood, after an examination of *Bærocrinus*.

The original generic description of *Bærocrinus* by Volborth contains little information respecting the arrangement of the plates in the calyx, of which the greater part in the type was concealed by matrix. Volborth distinguishes *Bærocrinus* from *Hybocrinus dipentas* by the greater size of the body and slight differences in the structure of the arms. He describes also a peculiar "elliptic organ," placed along the lower corners of two adjoining radials and across the angle of the adjacent basal. This so-called "Volborth's organ" stands somewhat elevated above the calyx, where it forms a kind of excrescence upon the surface. It is said to be closed by numerous small polygonal pieces, so arranged that their sutures are nowhere continuous with the sutures from the adjoining larger plates.

Upon this peculiar organization, mainly, which Volborth took to be either a madreporic body or a genital organ, the genus *Bærocrinus* was established.

In 1867, Grewingk brought forth an amended description of *Bærocrinus*. He had succeeded in cleaning the Erras specimen from its matrix, and this had enabled him to examine the form of the body and the construction of the plates, of both of which he gave figures and diagrams. He declared Volborth's organ to be a monstrosity, and undertook to prove this by the irregularity in the arrangement of the so-called plates of which it consists. According to his version, it is composed of about eighteen pieces, of the most irregular form and size, some of them pentagonal, some hexagonal, others rounded, and all without definite arrangement. He further states that the sutures from the adjacent radials and the basal plate are not continued within its limits, and that nothing leads to the conclusion that these plates meet with each other, like the remaining radials and basals of the specimen. He thinks the swelling is produced by the breaking up of the plates surrounding it, and he finds that at least some of the cracks do not pass entirely through the walls. He describes the calyx as composed of five basals and five radials, the latter arranged in a continuous series, but three of them only provided with an articular facet and arm-bearing. Among his figures there is a diagram (fig. 2*d*) showing the outline of the body as it appears at the upper edge of the radial plates, which is triangular, with straight sides and rounded angles. The angles represent the protruding arm facets of the three arm-bearing plates, while the two non-arm-bearing pieces form a part of the sides of the triangle. Looking at this figure, and afterward at fig. 1*c*, which gives the same view of "*Hybocrinus*" *dipentas*, which is represented with a strictly pentagonal outline, the contrast appears to be most striking; but in his description Grewingk pays little attention to this feature, and only mentions it by stating that the form of the calyx is "globular, with the exception of the upper rim which is triangular." Volborth seems to have considered the five large radials, of which only three are arm-bearing, and to some extent perhaps the "ellipische Ausschnitte zwischen den Klammern der Armglieder," the principal generic characters of *Bærocrinus*.

Schmidt, who wrote in 1876, considered the Erras specimen an abnormal and imperfect form of "*Hybocrinus*" *dipentas*. He had seen in the collection of Volborth three specimens from Palowsk, which possessed only four arm-bearing radials—that of the right anterior ray having no arm facet—together with others in which all five radials were developed, and he took the former to be an important link between the five-armed

specimens and the three-armed one from Erras. As to the absence of the small posterior radial, he thinks it may have been lost in the specimen. He attributes Volborth's organ to mechanical causes and deems it to be of no value specifically or generically. According to his statement, the calyx bulges out and is torn up by rents and cracks, which follow all possible directions, forming small irregular plates, and that some of the cracks extend deeply into the surrounding plates (fig. 1 on pl. 1). Schmidt explains the "Ausschnitte" between the arm joints in the Erras specimen as incidental breaks, which he attributes to the delicacy of the plates toward the articulation. Nothing is said about a difference between the two types in the form of the body.

According to Carpenter, the last writer upon the subject, the cylyx of *Bærocrinus* "consists of ten plates, which are arranged in two alternating rows without any indications of anal plates," and he remarks—"this does not agree at all with Billings's analysis of the *Hybocrinus* calyx." He says further: "*Bærocrinus*, if rightly described by Grewingk, represents to my mind an altogether different generic type," and "occupies a somewhat unique position among the Crinoidea. It is, perhaps, best regarded as a permanent larval form, which has only developed three of its five arms." And he says of Volborth's organ—"it struck me as possible that it may represent the anal opening, which does occupy a somewhat similar position between the radials and basals at one period of Crinoid development." He also alludes to the triangular outline of the calyx in *Bærocrinus*, and the pentangular form in "*Hybocrinus*," which he thinks additional proof that the two are distinct types.

It seems that Carpenter's arguments for separating *Bærocrinus* from "*Hybocrinus*" (Hoplocrinus) are based upon the following points: The former has no anal plates; only three arm-bearing radials; possibly an anal opening between basals and radials; and the calyx has a different form. It has been stated that neither Grewingk, who gave a cross section of the upper part of the two specimens, nor Schmidt, who saw those figures and examined the original specimens, attached any importance to the form as a distinguishing character, and it seems to us that a careful comparison of Grewingk's figures 2*d* and 2*b*, which both represent the Erras specimen, disclose the fact, that the trigonal outline of figure 2*d* does not extend much beyond the very edge of the calyx; that the cross section beneath the arm facets is pentangular, or as much so as in the Pulkowa specimen, and that even the upper edge would represent a similar outline if the two non-arm-bearing plates had been provided, like the other three, with protruding facets.

We think the trigonal form in this case is fully explained by the absence of these two facets. The outline could not be otherwise, and for a similar reason it must be quadrangular in the four-armed Palowsk specimens.

The non-development of a radial, which is found occasionally among specimens of the early types, is evidently, as Carpenter admits, due to their low organization, but for the same reason this feature cannot be of much value in considering the generic or even specific relations of these forms.

Carpenter's suggestion that Volborth's organ was perhaps the anal opening seems to us to be sustained neither by embryology, nor by its own structure. When the Pentacrinoid larva of *Antedon* assumes the crinoidal type, almost contemporaneously with the development of the first radials, there appears between two of the latter plates, and on a level with them, an irregular single anal plate. Somewhat later this attains an elliptic form, and is gradually lifted out from between the first radials, until it becomes developed into a conspicuous funnel. At the end of *Pentacrinoid* life the anal plate disappears entirely, being removed by absorption over the whole body.*

We find a close analogy to the anal plate of the young *Antedon* in the simple, large anal piece of *Hexacrinus* and *Dichocrinus*, in which that plate occupies the very same position, and is surmounted also by a funnel-shaped tube; but we confess that we fail to find any such analogy in the so-called organ of Volborth. In the Erras specimen there is, in place of the one plate, a multitude of plates of the most doubtful origin, and these occupy what ordinarily would form the junction between two radials and a basal plate. We find no indication of an aperture, and none is mentioned by either Volborth or Grewingk. Schmidt's figure, pl. 1, fig. 1, which is probably the most reliable, shows a long gaping crack through the middle part, but this is evidently a break and no regular organic structure. The irregularity of all these plates seems to us also a serious objection to Carpenter's view, as the small plates surrounding the anal aperture, in all Palæocrinoids, are arranged with the utmost regularity, and in all cases where there is a lateral opening, their arrangement presents a strictly bilateral symmetry. All this leads us to think, that we cannot be far amiss, in considering Volborth's organ, as Eichwald, Grewingk and Schmidt have done, to be an abnormal structure, due to mechanical agencies. Its protruding form would indicate that this force must have been pressure from within, and hence that this structure, very probably, may represent an abnormal anus,

* Researches in the Structure, Physiology and Development of *Antedon* (*comatula* Lamark) *rosaceus*, by W. B. Carpenter, M.D., F.R.S., Philosophical Transactions of the Royal Society, London, clvi, pp. 726 to 747.

formed when the regular anal opening of the specimen was functionally defective. We have frequently seen specimens, particularly among Actinocrinidæ, in which the anal passage had been obstructed, and a new opening had formed by breaking through the test at some other place. In one remarkable specimen of *Actinocrinus*, which has been noticed already by one of us (this Journal, vol. xiv, p. 127, Aug., 1877), the new opening penetrated the calyx along the basi-radial suture, between the first anal plate and the right posterior first radial, forming a large excrescence, composed of numerous irregular pieces; while in other specimens similar openings protrude but little above the general surface of the calyx. In every case in which this sort of anus has been observed, whether passing through the vault or the calyx, it is found to be located within the anal interradius, and hence we may safely assert that if Volborth's organ served such an office, the side which it occupies is the anal side, and that the non-arm-bearing plate toward the left is an azygous plate, and not a radial as suggested by Carpenter and the other writers. If it is a radial, *Bærocrinus* represents an exceptional type. It was Carpenter himself, who together with R. Etheridge, Jr. (Ann. and Mag. Nat. Hist., April, 1881, p. 295), first pointed out, that in Paleozoic Crinoids the symmetry of the calyx was more or less disturbed by the presence of an azygous or anal side, and this was the most constant character for distinguishing the Palæocrinoidea and Neocrinoidea. Now, if *Bærocrinus* is composed of five basals and five radials without an anal plate, it surely would represent one of the most symmetric forms of the Palæocrinoidea, such as are rarely found except toward the close of the Sub-carboniferous.

We offer the following amended diagnosis of *Bærocrinus:*

Calyx composed of five large nearly equal basals, and a row of five other plates forming a second circlet. The plates of the latter consisting of four radials, three of them—perhaps sometimes four—arm-bearing, and a large undivided azygous plate of similar form as the radials. The plate, which in other genera represents the right posterior radial, is not developed. Arms similar to those of *Hoplocrinus* and *Hybocrinus*.

Comparing this formula with that of *Hoplocrinus*, there seems to be a wide difference between the two types. But looking at the diagrams, figures 1 and 2, and remembering that in *Hoplocrinus* one of the large radials, as shown by Schmidt, is occasionally not arm-bearing, we find that a single suture drawn across the right upper corner of the undivided azygous plate of *Bærocrinus*, transforms this genus into a species of *Hoplocrinus* with four or five, as the case may be, arm-bearing

radials. However, it is scarcely probable that the division of the plate actually took place; it is more likely that the right upper corner of the azygous plate was gradually absorbed by the radial. This view is corroborated by the small size and peculiar shape of that radial in *Hoplocrinus*, and a comparison of this with the same plate in *Hybocrinus*, in which it has absorbed a greater portion, and attained somewhat more the shape of an ordinary radial. In the latter genus the upper left corner of the azygous plate has become divided off into a special anal plate. In figures 4–11, representing the azygous side of some of the later genera, the posterior radial grows larger by absorbing more and more the azygous plate until this, and at last also the special anal plate, disappears entirely at the dorsal side.

In our analysis of *Bærocrinus* we have taken the absence of the right posterior radial to be a fixed character. It may be, however, that in the Erras specimen this plate, exceptionally, was undeveloped, which is not improbable in such a low and early type. In that case the Erras specimen would be an imperfectly developed *Hoplocrinus*, and only a link toward a still more simple form in which that feature is constant. We will not undertake to decide, without seeing the specimens, whether under these circumstances the Erras specimen would be specifically identical with *Hoplocrinus dipentas;* we might say, however, that there is apparently no serious objection to it, and this shows how closely the two types run together, and that *Bærocrinus* is not that aberrant "altogether different type" which it was regarded by Carpenter.

The accompanying figures show the arrangement of the plates of the azygous side in the principal genera of the Cyathocrinidæ.

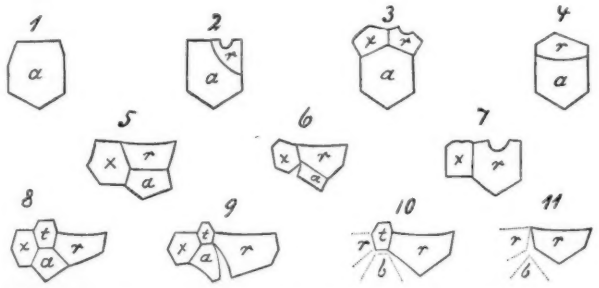


Fig. 1, *Bærocrinus;* fig. 2, *Hoplocrinus;* fig. 3, *Hybocrinus;* fig. 4, *Iocrinus;* fig. 5, *Dendrocrinus;* fig. 6, *Homocrinus;* fig. 7, *Cyathocrinus;* fig. 8, *Poteriocrinus;* fig. 9, *Eupachycrinus;* fig. 10, *Ceriocrinus;* fig. 11, *Erisocrinus.* The letter *b* means basals; *a*, azygous plate; *r*, posterior radial; *x*, special anal plate; *t*, first plate of the anal tube, more generally known as third anal plate.

In *Iocrinus* (fig. 4), the arrangement is somewhat like that of *Hoplocrinus*. The right posterior radial is almost as small as in that genus, but in place of occupying the corner only, it extends over the whole width of the azygous plate, from which it is separated by a horizontal suture. There is no special anal plate, the ventral tube rests upon the left sloping side of the radial, and as the tube has no connection with the azygous plate, we suggest that possibly the radial may embrace an undivided anal piece.

In *Dendrocrinus* (fig. 5), the case is similar to *Hybocrinus*, but the azygous plate is comparatively much smaller than in that genus, being largely replaced by the anal plate which at one side extends down to the line of the basals. The posterior radial and the azygous plate combined resemble in form the radial in the four other rays, being of about equal size and separated by a horizontal suture.*

In the Upper Silurian *Homocrinus* (fig. 6), the azygous plate is reduced to a small quadrangular piece, resting obliquely against the right posterior radial, against the anal plate and two basals. The anal plate is large and connects with the basals, and these touch the adjacent radial.

In *Cyathocrinus* (fig. 7), which appears in the Upper Silurian and survives the Sub-carboniferous, the azygous plate, which in *Homocrinus* had been already greatly reduced in size, is absorbed wholly by the posterior radial, and there is left only a large special anal plate. In this genus, contrary to the preceding ones, and those of other Cyathocrinidæ which have an azygous piece, the right posterior radial has the same form and size as the one toward the left.

In the preëminently Sub-carboniferous genus *Poteriocrinus* (fig. 8), we find an azygous plate, but this is pushed out still more from beneath the radial than in *Homocrinus;* its form is pentagonal, owing to an additional plate, which rests upon its upper truncate side. This plate, which is hexagonal and best known as the third anal piece, is actually a plate of the ventral tube incorporated within the calyx. The anal plate, which is smaller than in the two preceding genera, is hexagonal, and alternately arranged with the azygous plate and the plate above.

In the typical *Eupachycrinus* (fig. 9), the case is almost the same as in *Poteriocrinus*, only the azygous plate is compara-

* In Revision I, pp. 65–75, we considered the combined right posterior radial and the azygous plate in *Dendrocrinus*, which in their position and proportions resemble the right posterior radial in *Cyathocrinus*, to be a compound radial. At that time we thought that the second, the so-called azygous plate, in *Dendrocrinus, Homocrinus*, and in the Cyathocrinidæ generally, was a modified radial, and also that the anal tube, possibly, had been developed from an arm. Upon these points we were evidently in error.

tively more developed. This is somewhat remarkable, as *Eupachycrinus* is one of the latest known forms of the Palæocrinoidea, and, apparently even within the limits of this genus, or contemporaneously with it, we find all the gradations, from the most extravagantly developed anal side to its simplest forms. Aside from the irregular symmetry, which evidently represents a retrogression, the species show in all respects that they belong to one of the highest types of the group, and particularly in their mode of articulation they are fully up to the Jurassic Neocrinidea.

In fig. 10, a form which has been generally included with *Eupachycrinus*, but has been very properly separated by Dr. White under the name *Ceriocrinus* (Contributions to Palæontology, No. 6 (1880), p. 127), both the azygous and the special anal plate are absent, and only the small third anal retains its usual position, which extends partly beyond the limits of the radials.

In *Erisocrinus* (fig. 11), one of the last survivors of the Cyathocrinidæ, the calyx is perfectly symmetrical, the azygous and anal plate being entirely absorbed by the other plates.

The different phases in the Paleontological development of the azygous side to which we have here alluded resemble most remarkably the stages of growth in the anal arrangement of *Antedon* during its Pentacrinoid life. At a time when even the radials were yet imperfectly developed, we find in both forms a large anal (azygous) plate (*Bærocrinus*), which is lifted out from between the radials (*Hybocrinus*) and becomes developed into a conspicuous funnel (the later Cyathocrinidæ), until at the termination of Pentacrinoid life and the close of the Carboniferous, the anal plate disappears entirely. The gradual disappearance of this plate in the growing animal is represented paleontologically by the modifications which take place in the form and size of the plate, and these modifications represent important generic characters. It must be stated, however, that the "anal" plate of the young *Antedon* is evidently not the homologue of the plate in the Cyathocrinidæ which we have designated as the "special" anal plate, but that it is the equivalent of the undivided azygous plate in *Bærocrinus* and *Hoplocrinus*. We further hold that the special anal plate in *Hybocrinus* is the first step toward a plated tube which in that genus is reduced to its minimum size, consisting of only a single plate. The diminuitive tube possessed in its crenulated, rhomb-like structure an organization similar to that of the later genera in their large porous sac composed of numerous plates, and it is probable that both structures performed the same functions, and these may have been identical with those of the rhombs in the Cystidea.

ART. XLII.—*Evolution of the American Trotting Horse;* by W. H. PICKERING.

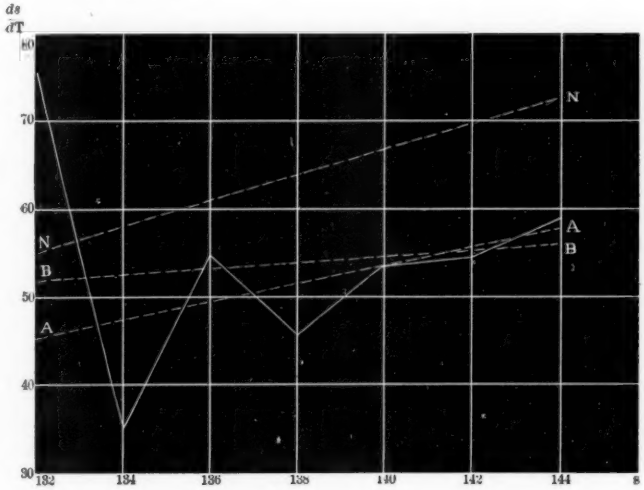
THE two articles which have appeared on the above subject in the July and August numbers of this Journal have but just come to my knowledge, as I have been absent from the city for several weeks. Mr. Nipher has dealt with the question in a somewhat different manner from myself (see Science, May 4th), and has arrived at quite different results.

According to my calculations the value $\frac{ds}{dT}$ (s = seconds, T = years), instead of diminishing was nearly constant, with a slight tendency to increase. Or, in other words, horses were improving their speed slightly more rapidly now than they were a few years ago. This of course might readily be explained by the greater care bestowed in breeding and by greater attention being paid to the subject now than formerly. This could not last for many years, however, and the value of $\frac{ds}{dT}$ must finally diminish to zero. But in the mean time we have no means of saying how soon this will take place, or what will be the value of s. According to my work we could only predict what speed would be made in the course of the next few years, and it was concluded, for example, that two minutes would be reached about the year 1907.

Instead of taking his dates directly from the races, Mr. Nipher prefers to interpolate them from some curves which he has calculated. If all the observations contributed by Mr. Brewer could be included in this scheme, it would undoubtedly be the best method. As it is, it limits our author confessedly for accurate work, between the dates 1854 and 1873, whereas, the direct method is capable of including all observations from 1824 up to the present time. It therefore seems to me that the greater number of observations more than compensates for the greater accuracy of the few. And indeed I think this is indicated by the fact that we shall be able to draw quite a different conclusion from our author, though using the results obtained by his own method, while, by using all the observations as in my former article, I think but one conclusion can be drawn.

At the top of page 22 (July number), Mr. Nipher gives a table, the third column of which $\frac{ds}{dT}$ he calculates from alternate differences in the first two columns. Now where there are so few observations I think this method is hardly of sufficient accuracy, and that it is somewhat better to divide the

first differences of the first column, by those of the second, directly. By so doing the figures in the third column will read 59, 55, 54, 46, 55, 35, 75. This method does not smooth down the curve at all, but shows it with all its original irregularities. Plotting now a curve with these figures as ordinates, and the corresponding values of s as abscissae, we get the following figure:



These results could evidently be represented by a curve. And they show what mine did, only I think in an exaggerated way, the increasing value of $\frac{ds}{dT}$ within the last few years. Mr. Nipher, however, prefers to represent them by a straight line. This line N is shown upon the plate, calculated from his values of a and b. Following him in this respect, two lines of my own A and B are also given. Now there are two methods by which we may determine approximately the accuracy with which a line represents a series of observations. First, that while the line coincides as nearly as possible with the points observed, the algebraic sum of the ordinates should be zero; and second, that the sum of the squares of the ordinates should be reduced to a minimum. Making these calculations we obtain the following results:

	N	A	B
Sum of the ordinates	72	15	1
Sum of the squares	1900	1073	931

In both particulars we find that B best represents the results, and it is the line having the least inclination. We therefore conclude that $\frac{ds}{dT}$ is diminishing very slowly. Calculating its equation we find $\frac{ds}{dT} = \cdot 084 + \cdot 0033\ s$. According to this, $\frac{ds}{dT}$ can only become zero when $s = -25$, or in other words the speed of the trotter will only cease to improve when he trots a mile in minus twenty-five seconds, or in less than no time at all.

I therefore maintain that Mr. Nipher's method, if correctly interpreted, gives in general the same result as my own. By it we may foretell what will be the speed attained for a few years in advance, but we cannot tell what will be the ultimate speed, nor when it will be reached.

Institute of Technology, Boston.

ART. XLIII.—*On the Discovery of Utica Slate Graptolites on the west side of the Hudson a few miles north of Poughkeepsie;* by Mr. HENRY BOOTH.

DURING the construction of the West Shore Railroad, on the west bank of the Hudson River, the large number of cuttings made afforded a good opportunity for examining the slate and limestone rocks between West Park and Cornwall.

At two points small beds of Graptolites were found by Mr. C. Lown, of Poughkeepsie, and myself. The localities were nearly obliterated by the workmen, but we obtained some specimens which were referred to Professor R. P. Whitfield, of New York. Enclosed is his letter, giving the names of the graptolites submitted to him.

The localities are, one at Blue Point, about two miles south of New Paltz Landing (now called Highland), and one about a mile north of the same place.

Poughkeepsie, N. Y., Sept. 29th.

Copy of Letter from Mr. R. P. Whitfield, dated American Museum, New York, August 28th.

I find among the Utica Slate Graptolites sent me, *Diplograptus pristis* Hall (not of Hisinger); *Climacograptus bicornis* Hall; *Dichograptus furcatus* Hall; *D. divaricatus* Hall?; *Monograptus gracilis* Hall; *M. sagittarius* Hall, and *Diplograptus marcedus* Hall?.

Art. XLIV.—*Becraft's Mountain;* by William Morris Davis.

Previous opinions concerning this locality—Formations occurring here—Their absolute and relative positions—Question of nonconformity between Lower and Upper Silurian—Notes on the accompanying map—Relations of Lower and Upper Silurian elsewhere.

Becraft's Mountain is a small, low outlier of Lower Helderberg limestones, resting on the Hudson River formation, two miles east of the river and about a mile southeast of the city of Hudson, Columbia county, New York. If the name apply to all the limestone area, it would include an oval mass nearly two miles long, north and south, and over a mile wide, low on the ends but bordered with strong bluffs from fifty to one hundred and fifty feet high on the sides. The interest in the locality arises not so much from the isolated position of the limestones, as from the reported nonconformity between the strata of Lower and Upper Silurian date. The previous descriptions and figures of the mountain are collected in my paper on the Folded Helderberg limestones east of the Catskills (Bull. Mus. Comp. Zool., Cambridge, Geol. Series, i, 318, 1883); it will here be sufficient to mention that Mather, Rogers and Dana described it as showing an unconformity, while Emmons showed the contact of the upper and lower rocks conformable, and Hall was disposed to take this view. The figures given by Mather are very rough, and the one (Geol. N. Y. 1st Distr., pl. 24, fig. 6) showing a complete cross-section, seems to be generalized on a very theoretic basis.

During a recent recess in college work, I took opportunity to visit this locality with a party of students, to see how clear the evidence might be in favor of one or the other of the above views, and in two days spent on the ground obtained the following results.

The formations occurring in this region are, beginning with the oldest:—1. The so-called Hudson River group; shales and shaly sandstones, with much fine jointing or rough cleavage that might often be well mistaken for bedding; sometimes showing clear bedding as well, which is then generally even, though in some outcrops it seemed very irregular and was there flinty and indurated. The outcrops were very few compared with those of the overlying limestones, as heavy terraces of stratified drift surround the base of the hill. No fossils were found in this formation, and in using the name "Hudson River" I simply take that which is most generally accepted.

2. The Lower Helderberg limestones, consisting of:—

2*a*. Tentaculite limestone, probably including the Ribbon limestone and possibly some equivalent of the Water-lime; fine, blue, even, thin beds, weathering light-colored and smooth. A few imperfect *Leperditiæ* were found in it. Thickness, twenty to thirty feet. No representative of the Coralline limestone was noticed at the base of this subdivision.

2*b*. Lower Pentamerus limestone; heavy, knotted, grayish-blue beds, with irregular nodules of chert. Fossils were not common, but *Pentamerus galeatus* and *Atrypa reticularis* were found at several places. Thickness, forty to fifty feet.

2*c*. Catskill Shaly limestone; deep blue, weathering brown and shaly; generally showing its many fossils as casts. *Spirifer macropleura*, *Hemipronites radiata* and *Strophomena rugosa* being most characteristic among many others. Thickness, fifty to sixty feet.

2*d*. Upper Pentamerus limestone, probably with representatives of the Encrinal or Scutella limestone; a hard, gray, crystalline limestone, largely made of fragments of shells in somewhat even layers. *Spirifer medialis*, *Orthis* ——— and *Pentamerus pseudo-galeatus* are most easily identified. This rock is quarried as 'shell-marble,' and is cut by steam drills into large blocks as much as five by five by twelve feet; it is also burnt for lime, and used in smelting iron ores at Hudson. Thickness, forty to fifty feet.

3. Cauda-galli shales; barren, gray, monotonous shales, seldom showing any trace of bedding, but breaking on an irregular, nearly vertical cleavage. No fossils. Thickness, one hundred and fifty to two hundred feet. This formation has not been previously mentioned as occurring here.

4. Corniferous limestone; a hard, cherty limestone lying on the Cauda-galli shales over a small surface, and doubtfully referred to this formation. No fossils. Thickness, ten to fifteen feet.

5. An unknown conglomerate of limestone fragments in a compact siliceous matrix. The fragments were tolerably well rounded, and seem to correspond with the several subdivisions of the Lower Helderberg. Only two localities of this deposit were found, both of them outside of the bluffs; one making a low mound in the meadow at the left end of section I; the other in the irregular mounds (F on map), a quarter of a mile south of the southern limiting road. At neither point could the position of the bedding be determined, and no conclusion was reached as to the age of the deposit, except that it is apparently younger than the Helderberg series and certainly much older than the drift. It is apparently to this that Emmons makes reference (Agric. N. Y., i, 1846, 136).

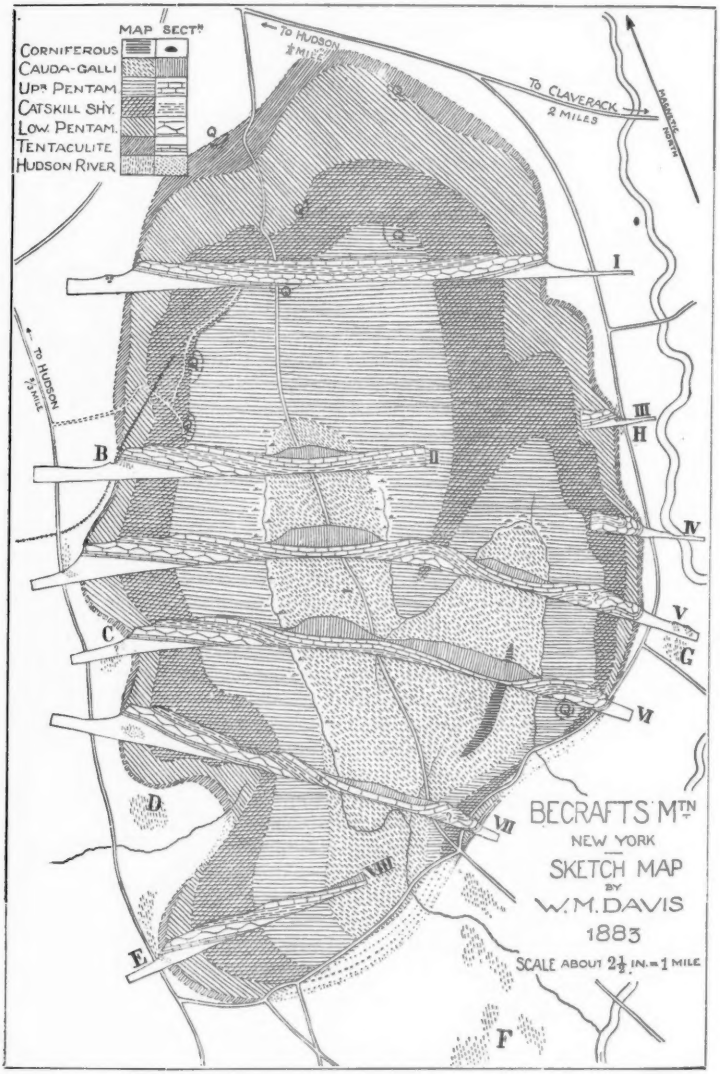
6. Drift; seen chiefly in the stratified sands of the terraces

that are two or three hundred feet above the river. Erratics were commonly quartzites and granitic rocks, often garnetiferous; some of these were scratched. None of the ledges were striated, nor could we expect to find them so, as all had been long exposed and were well weathered.

The position of the several formations may be described as follows:—

The Hudson River strata have as a rule a regular northerly strike east of the river, and are generally found with a steep easterly dip; at several points a few miles to the west and southwest they rise in ridges of greater height than the crest of Becraft's Mountain, but on the east, their surface is lower and is seldom exposed on the railroad between Hudson and Chatham.

The limestones form a flat synclinal, about a mile and three-quarters along the axis and over a mile broad, with the middle line trending N. 20° E. (magnetic bearings given in all measures), and the greater heights on the western side. On the east, small subordinate folds are added, each one more distinct on the southeast and fading away to the northwest; and, when taken together, showing an increase in sharpness toward the southeastern border, where they follow one another in rapid succession, always with the steeper pitch of the anticlinal on the west, and with overthrown dips at several points. The distinctness of this small imitation of Appalachian structure is surprising. Excepting at the northern and southern ends, where the margin of the limestone is somewhat doubtfully inferred, the outcrops always appear in the form of pronounced bluffs, rising on the southwest where highest about two hundred feet above the terrace plain. The Tentaculite and Lower Pentamerus generally make the outermost and strongest bluff together; the Catskill shaly limestone and the Upper Pentamerus form roughly concentric ridges at variable distances inward from the margin; the Cauda-galli shales make smooth, round hills southward from the middle of the oval area within the bluffs. The more complicated structure of the southeastern side is not clearly revealed in its form, and requires close observation of dip for its determination. I am not sure that there should not be one more small fold there than is represented in the sections. There is no sufficient evidence of faults such as Mather shows on both his sections. The axis of the general synclinal dips gently to the south; at its northern end the limestones lie essentially horizontal; but at the southern, where exposed, they are turned up abruptly so as to stand on end with a strike varying from W.—E. to N. 70° E. This abrupt folding may be torn into a fault on part of its length as the limestone outcrops are wanting on much of the distance where they should appear.


MAP SECTⁿ
CORNIFEROUS
CAUDA-GALLI
UPR PENTAM.
CATSKILL SHY.
LOW. PENTAM.
TENTACULITE
HUDSON RIVER
TO HUDSON
TO CLAVERACK
2 MILES
HAMMONDSPORT
TO HUDSON
I
II
III
IV
V
VI
VII
VIII
H
G
B
C
D
E
F
BECRAFTS MTN
NEW YORK
SKETCH MAP
BY
W. M. DAVIS
1883
SCALE ABOUT 2½ IN. = 1 MILE

The relative position of the Hudson River strata and the overlying limestones is the point of most importance and interest, and the weight of evidence here seems to be in favor of nonconformity, though this relation is not nearly so well shown here as in the remarkable exposure in the old cement quarries at Rondout, on the other side of the Hudson, about thirty miles farther south.

The following observations show what was found at all the outcrops below and in the neighborhood of the limestone bluffs.

A. In a cut on an old quarry railroad, a quarter of a mile west of the limestone bluffs (not included on the map); shaly layers, strike N. 25° E., dip 35° to E.S.E.

B (see map). In another cut of the same old railroad, directly under the western bluff, as the road rises obliquely along the slope to reach the quarries; shaly outcrop, N. 55° E., dip 25° to S.E. A few hundred feet farther up grade or northeast, the cut shows the lower layers of the Tentaculite limestone, N. 35° E., dip 15° S.E. This variation of position is not significant, for equally great variations are found in the limestone itself in passing short distances along the cliff face at many points. The cut here reveals a considerable depth of talus fragments, often including large blocks that might be taken for ledges in place if not fully exposed, and show how difficult it would be to find a natural contact underneath the bluffs.

C. In a little stream channel leading down from a depression in the bluffs, a few hundred feet south of a glue factory; the Tentaculite stands N. 23° E., dip 15° E.S.E., at base of limestone outcrops, and about twenty feet from it the shale appears, but unfortunately shows nothing but cleavage, N. 25° E., dip 50° E.S.E.; however tempting it may be to assume that the cleavage and bedding coincide, there is not the least evidence that they do. The steeply inclined splitting of the horizontal Cauda-galli shales within the limestone synclinal shows how entirely untrustworthy this appearance may be as a guide to the position of stratification. On the road-side, about half way from B to C, the bedding was N. 25° E., dip 30° E.S.E.

D. On a mound on the northern side of the entrance to a deep valley near the southwestern end of the mountain. The limestones are here nearly horizontal; no contact is found, but about forty feet down the slope from the lowest visible layer of the Tentaculite, there are numerous small outcrops of a very uneven, indurated, flinty rock, for which no position could be determined satisfactorily. Its irregularity would, however, indicate unconformity. Similar small patches of indurated slaty rock, from which the bedding has disappeared, are found near the road on the other side of this valley.

E. At the southwestern end of the mountain, a small opening

on the road-side exposed the Tentaculite with a faint easterly dip lying with smooth contact, about ten feet long, on hard slaty rocks, in which the appearance of bedding was N.—S., dip 50° E. The face of the rocks was so weathered and jointed that it was difficult to make sure that the contact was a true unconformity and not a slip.

F. A third of a mile south of the limestones, several irregular mounds (a few outcrops of the limestone conglomerate were found on one of them) rising among the terrace flats show the same indurated, flinty outcrops as were found at D. Some beds were found standing N. 25° E., dip 40° E.S.E., and smaller outcrops continued toward the limestones, across the creek that flows out from the synclinal. These seem to show that the older rocks maintain a northerly strike where the limestones turn around toward the east.

G. A few hundred feet southeast of the outlier, the sandy shales rise in small ledges, with a tolerably well-defined bedding, N. 50° E., dip 60° S.E. This conforms fairly with the nearest limestone, if we suppose it to have an overthrown dip, as is not at all improbable.

H. A small cutting on the side of the eastern road uncovers shales with a faint easterly dip. About fifteen feet higher up the bank the lower limestones are inclined gently to the west. The difference between the two is very small, and is fully equalled by differences in the position of adjacent limestones a little farther south, where the folds are crowded together.

From this point, around the rest of the circumference, no outcrops of the older rocks were found, although the whole distance was carefully searched.

The observations thus detailed may be summarized as follows: A, C, and G are non-committal; if necessary they could agree with either conclusion. B and H, if seen alone, would be taken as decisive of conformity. D, E and F imply unconformity, but with nothing of the distinctness shown in Mather's section. It is notable that these three outcrops show a much more indurated and irregular rock than the others; and one could easily suppose them to belong to a series independent of and unconformably below all the others, shaly sandstones as well as limestones. Indeed, this seems to be the conclusion reached by Emmons. He wrote: "Another limited fracture appears on the southeastern side of Becraft's Mountain, about three miles southeast of Hudson. On one side the Taconic slate appears supporting a fragmentary mass of Calciferous sandstone; on the other, the inferior members of the Helderberg division, the thin bedded Water-limes and Pentamerus, beneath which are the gray sandstones of the Hudson river" (Agriculture of New York, i, 1846, 136). The evidence of

such a fracture is indistinct, and the identification of the limestone conglomerate apparently at our locality F with the Calciferous is certainly hazardous. Fossils being absent and outcrops few and scattered, it is difficult to find observations that shall compel a single explanation. Perhaps further exploration of the other Helderberg outliers of which Mather makes brief mention may aid in solving the question.

A few words may be said concerning the accompanying sketch-map and sections. They are based on estimated distances and compass bearings taken all around the bluff outcrops, and on many zig-zag section lines within the limestone area. While the drawings cannot claim close accuracy, they nevertheless combine very successfully all the observations made on rocks, roads and streams. The sections are placed directly where they belong on the map, as more seems to be gained by showing them in their true positions than is lost by breaking the continuity of the map surface. The Helderberg rocks are constructed in their probable position underground, but the Hudson River strata are shown only at their outcrops. The part of least accuracy is on the southeast, where the folds produce more complexity than could be unravelled in the time we had on the ground. As already mentioned, the strip of limestone called 'Corniferous' is so named only because it is cherty and lies on the Cauda-galli shales; but the identification is very probably correct. The Hudson branch of the Boston and Albany railroad passes a little distance northeast of the map, within clear view of the Lower Pentamerus bluffs.

The relations of the Lower Helderberg to the Hudson River formation are somewhat peculiar in connection with the occurrence of Silurian non-conformity. When the full series of Silurian deposits is represented, the two groups in question are separated by several intermediate formations—the Oneida, Medina, Clinton, Niagara (these four belonging to the Niagara period) and the Salina—which attain a total maximum thickness of several thousand feet, and consequently imply the passage of a long interval of time. The only part of this interval marked by disturbance is between the Hudson River and the Oneida epochs, but this disturbance does not seem to require the absence of any known part of the series. The following review of contact-localities will show this. On the northern face of the Helderberg Mountains, the formations of the Niagara and Salina periods are essentially wanting, and the Lower Helderberg limestones rest on the Hudson River shales, separated only by a few feet of transition deposits, all the strata being horizontal; the junction here has always been described as conformable, in spite of the long time that passed without deposing its record. Whether the actual contact has been

observed or not does not appear, nor has there yet been given any satisfactory explanation of what was going on here during the long unrepresented time. This conformity was found also near Catskill in the folded strata east of the Catskill Mountains, in Green county (see my paper above referred to). At Rondout, Ulster county, a fine, uneven unconformable contact is clearly shown in the old cement quarries, where the entire Niagara and Salina groups are represented by only about six feet of limestone; another is noted at Otisville, N. Y., near the Pennsylvania line, in a cut on the Erie railroad (see Second Geol. Surv. Penn., G 6, 150), where the intermediate strata are seen in some force and the Oneida conglomerate lies on the Hudson River slates. Farther southwest, in Pennsylvania, fragments of the slates are found in the Oneida, and hence nonconformity is inferred, although the sudden variation of dip seen at some points on the southeastern slope of the Kittatinny Mountain that has heretofore generally been explained as a nonconformity, is now regarded by Professor Lesley as the effect of a fault (l. c.). In eastern Tennessee, the Lower and Upper Silurian are perfectly conformable, and the series of strata is fairly complete before and after the critical date. In southern Ohio, an uplift and erosion are described as occurring at the beginning of Upper Silurian time; and a similar but longer disturbance is reported in western Tennessee; but in both these localities, the older and newer strata are essentially parallel. Conformity and nonconformity are therefore quite independent of the presence or absence of certain members of the series; and absence of the upper members is independent of distinct dislocation of the lower members. With a tolerably full sequence of strata about the time of disturbance, there is normal conformity in eastern Tennessee, and nonconformity in southeastern New York and northeastern Pennsylvania; on the other hand, there is conformity in the Helderberg Mountains, and nonconformity at Rondout, although the intermediate strata are essentially absent at both these localities. Again, the strata are essentially horizontal and parallel in the Helderbergs, where the series is incomplete and undisturbed, as well as in southern Ohio, where the series is fuller, but where fragments of the lower are found in the upper members. Finally, the strata are folded and conformable with lapse of intermediate members at Catskill; folded and unconformable with similar lapse at Rondout; folded, unconformable and without lapse farther southwest. Other examples could be quoted from the Canada surveys. All combinations of these various elements appear, and there is therefore no necessity of supposing unconformity at Becraft's Mountain simply because the limestones there do not belong immediately after the shales in the geological series. Moreover, the gener-

ally flat position of the limestones and tilted position of the shales east of the Hudson does not decide the question, for the shales are twice seen almost flat under the limestones of the outlier, and on the southeastern side the limestones are strongly tilted. The suggestion above that the shales and slates are of different ages requires much further observation for its proof. This indefiniteness of indirect evidence is the more unsatisfactory from the incompleteness of the contact outcrops; and as it is very possible for an appearance of nonconformity to arise in a series that is all folded at the same time, on account of the unequal folding of adjoining strata of different resistances, nothing but direct and clear exposure of an uneven and surely unconformable contact will suffice finally to settle this point in the structure of Becraft's Mountain.

Cambridge, April 23, 1883.

Art. XLV. — *The Nonconformity at Rondout, N. Y.;* by W. M. Davis.

Description of the formations occurring here—Upper Silurian unconformable on the Lower—Altitude of the rocks and local topography—Glacial and surface geology.

The reference made in the preceding article on Becraft's Mountain to the clear evidence of the unconformable relation of the Upper and Lower Silurian rocks at Rondout on the Hudson suggests the publication of a more detailed illustration of this noted locality than has yet appeared. The accompanying map and sections are prepared with this object from notes taken during an excursion in April of this year, and with a short descriptive text these may serve as a supplement to the earlier papers by Lindsley* and Dale.†

The formations occurring here are in most respects like those at Becraft's Mountain and in the limestone belt west of Catskill, which I have already described;‡ the following notes will point out their local peculiarities. The Hudson River rocks are sometimes heavy-bedded sandstones of rather fine texture and considerable hardness, as in Huzzy's Hill, a ridge of several hundred feet elevation two miles south of Rondout; and sometimes shaly and much contorted, as along the banks of the stream at Eddyville. They occupy all the area east of Rondout Creek, with small exception, but are generally hidden under terrace rift. The Oneida conglomerate is represented

* Poughkeepsie Soc. Nat. Sci. Proc., ii, 1879, 44–48.

† This Journal, xviii, 1879, 293–295. Dale's figures belong near section II on our map.

‡ l. c., and Bull. Mus. Comp. Zool., Geol. Series, i, 1883, 311–329.

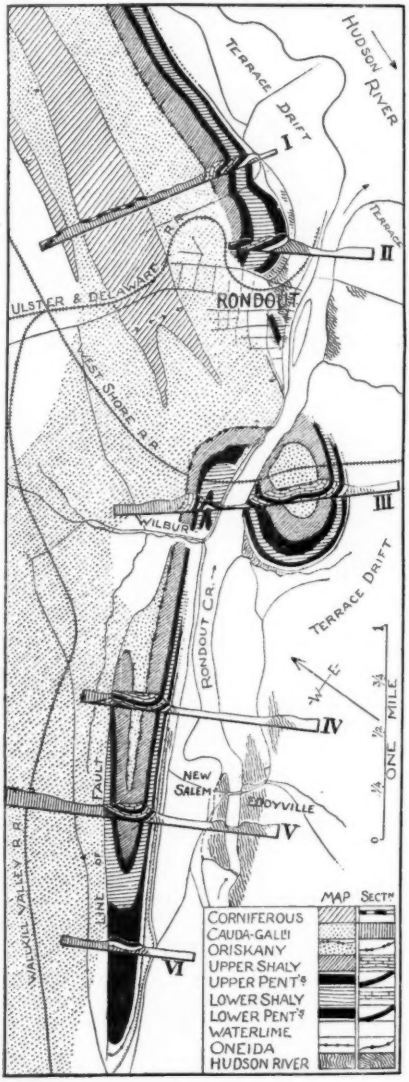
by a stratum of almost quartzitic texture, white or bluish in color, and fifteen to twenty feet thick. The most northeastern point where it was certainly recognized was in New Salem at the beginning of the horse-railroad leading to the cement quarries in Whiteport; thence southwestward it may be frequently seen at the foot of the limestone bluff, a hard, compact bluish quartzose rock. At the foot of the map, where the limestone ridge breaks down, it is white, and so appears again about two miles west in the fine anticlinal near Whiteport where the Water-lime has been deeply quarried. It holds no pebbles or fossils here and is not yet thick enough to have a noticeable effect on the topography.

The first of the limestones is seen in the quarry on the hill overlooking Rondout (Section II), where it rests directly on the Hudson River rocks, as will be further mentioned below. As measured by Mr. J. G. Lindsley, superintendent of the Newark Lime and Cement Co., it is six to eight feet thick, and from its abundance of corals it is considered the equivalent of the Coralline limestone of Schoharie, the thin eastern extension of the Niagara of Western New York.*

The Water-lime and Tentaculite, to which Lindsley adds the Stromatopora and Ribbon limestones, have a total thickness of seventy feet. The layers are generally smooth and even, espe cially in the upper part and are readily recognized, but fossils are not common. The lower beds are deeply quarried at numerous points in this neighborhood for cement-rock, of which a great quantity is burned, ground, barreled and shipped. The annual yield has in the past few years risen to 2,000,000 barrels, valued at about a dollar a barrel. The openings thus made give excellent views of the deep plunging of the strata into the earth, especially at the Whiteport anticlinal above referred to. At Catskill twenty-five miles north of Rondout the rock is not found adapted for hydraulic cement; and though therefore not economically *a* water-lime, I am confident that it is geologically *the* Water-lime. The Lower and Upper Pentamerus limestones, about thirty and forty feet thick respectively, generally retain the characters seen at Catskill and Becraft's Mountain; the Lower being heavy, uneven, cherty, with comparatively few fossils; the Upper being also heavy and somewhat uneven bedded, but rich in fossils and free from chert. These are separated by the Catskill shaly limestone, about sixty feet thick (Lindsley gives it only sixteen, which seems much too little), and overlaid by a similar formation, certainly over one hundred feet thick and probably as much as one hundred and fifty. These I have mapped as the Lower and Upper Shaly limestones; they are generally very impure, and hardly

* See J. Hall, Pal. N. Y., iii, 26, and Amer. Assoc. Proc., xxii, 1873, 321.

deserve the name of limestones; their outcrop is very ragged and the Upper Shaly sometimes weathers on cleavage instead of on bedding planes, giving a very deceptive appearance (as on the southwestern synclinal ridge); in spite of its shaly texture, it stands higher than the limestone below it. Fossils are not nearly so numerous as in the Shaly limestone at Catskill; but it is interesting to note that several characteristic species (*Spirifer macropleura*, *Strophomena rugosa*, *Hemipronites radiata*) common to both the Lower and Upper Shaly beds are absent or very rare in the intermediate Upper Pentamerus, and thus seem to confirm the supposition that both these shaly deposits were formed comparatively near the old shore line, which retreated eastward carrying its fauna along with it and so allowed the pure Upper Pentamerus limestone to form, and then came back again with its fauna unchanged, driving the deposition of pure limestone away to the west. The Upper Pentamerus is often deeply quarried for lime, as at the several points where Sections I, II and III cross it. The passage from one to the other of the above subdivisions of the Lower Helderberg limestones is comparatively gradual; but an abrupt



change at the top brings in the Oriskany sandstone and grits, about twenty and thirty feet thick, but variable. The lower member is sometimes absent, but when seen it consists of pure white quartz, sometimes dense, sometimes rather loosely built of subangular white pebbles up to one-third of an inch in diameter, without fossils. This is followed by a hard grit with casts of numerous fossils, among which *Spirifer arenosa* was most frequently found. As usual, the stone fences give the best collecting ground; for example on the ridge northeast of the West Shore bridge across the Rondout, and on the southwestern synclinal. Above this, we find the barren Caudagalli shales, lifeless but for the occasional sea-weed imprints; fine textured and generally with the bedding completely replaced by the characteristic steep cleavage plane. Its thickness is very probably three hundred feet or more. A fine exposure of these shales is found in a bold synclinal bluff advancing toward the creek between Rondout and Wilbur; from here to the railroad bridge, a good downward sequence of formations is exposed. The Corniferous limestone, recognized only by its fine texture, plentiful chert, and position, completes the series.

The interruptions in the sequence of formations at Rondout are of two kinds. One, that may be called passive, consisted essentially in withholding the supply of sedimentary material, so that certain epochs were left unrepresented: thus the Medina, Clinton and Schoharie deposits are completely wanting, and the Oneida and Niagara are almost absent. The other interruption came between the deposition of the Hudson River and the Coralline or Oneida strata and was of a much more active character; the Hudson River rocks were upheaved, exposed to erosive forces, presumably of the ordinary subaerial kind, and then submerged to receive the later formations on their worn edges. This is most excellently shown in the old quarry in the hill overlooking Rondout (at Section II) where the contact line has been perfectly exposed for ten feet or more; a fair inference of nonconformity

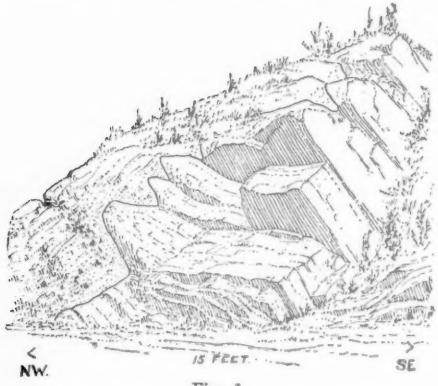


Fig. 1.

can be made at several other points along the slope. The rocks on the western side of the limestone outlier, opposite Wilbur, also give good evidence of non-conformity, but we found no contact there. This locality is described and figured by Mather. The irregularity of the contact in the Rondout quarry completely excludes the possibility of the disagreement of dips in the over- and underlying formations being due to a fault, at least at this point, for as shown in figure 1, the limestone fits closely into channels worn along the strike of the softer sandstone beds, and the two rocks are so firmly consolidated that hand specimens can be easily obtained showing the line of junction. It is noteworthy that the limestone begins immediately with its fully determined calcareous character: there is no band of transitional composition; no fragments of the sandstone are contained in the overlying rock. The old worn surface was swept clean before the corals and crinoids began growing upon it, and their fragments and grindings make the first deposit. Some little pieces of crinoid stems lie directly on the bare sandstones. From the absence of the Oneida sandstone here, it may be inferred that the Hudson River rocks remained out of the Paleozoic ocean longer at this point than they did two miles to the southwest of it, where the earlier Upper Silurian strata lie directly upon the Lower Silurian beds. At the end of the quarry-railroad in Eddyville, already mentioned, a contact is opened for nearly one hundred feet, but unlike the one at Rondout, it is even, and the rocks agree in strike if not in dip. It is therefore probable that this contact is not the original one, but has been produced by faulting or slipping when the rocks were folded. The possibility of such slipping is well shown in the deep quarry (Newark Lime and Cement Company) a little south of Section I, where the Water-lime is folded and slipped so as to be apparently unconformable to itself. The probability of such an occurrence at Eddyville may be inferred from the sharp folding that occurs all along the front of the limestone bluffs. On the other hand, it is also probable that, if an original contact could be seen, it would be truly unconformable, for this relation occurs on both sides of it; at Rondout on the northeast, and at Otisville on the Erie railway,* some forty miles southwest. At some later date, presumably contemporaneous with the great Appalachian disturbance, the entire series of rocks described above were folded and dislocated. The most pronounced effects of this deformation are now seen along the bluffs of Lower Helderberg limestones. Beginning at the northeast near the Hudson, the rocks either stand on end or dip strongly to the west; they fall to a less angle on approaching Rondout and then are for a time more or less hid-

* Geol. New Jersey, 1868, 135. Second Geol. Surv. Penn., G 6, 150.

den in passing through the town. Crossing the creek, they build the limestone outlier, a flat synclinal with steep or vertical dips on the eastern side, and then cross the stream again by the railroad bridge and plunge underground at a high angle. The anticlinal half of this S-shaped curve is not a simple turn, but is complicated by a small additional fold where the stream crosses Section III, as is shown on a larger scale in figure 2.

Fig. 2.

From here, up the valley, the strike is very uniform, and the bluff-front very even. Sections carried across it at several points showed a well-marked synclinal structure bounded on the northwest by a down-fault of moderate throw. In conformity with what seems to be "normal" for the Appalachians, this fault is drawn with the upthrow *overlying* the hade. By following along the axis of this synclinal from Wilbur, one passes over seven different subdivisions of the Upper Silurian that successively come to an end in the rising trough.

This detailed statement of the altitude of the rocks seems necessary in order to contradict the supposition not unfrequently made some years ago that a "great fracture" passed along the Hudson valley between the older and newer rocks. Apart from the folds and local faults of small throw there is no evidence whatever of any great disturbance, and the great fracture is purely hypothetical. The Oneida and Medina lose the mountain-making strength they possess in Pennsylvania because they thin out, not because they are cut off. The Cauda-galli shales cover a broad hilly surface back of the limestones, and in the northern part of the district examined they are overlaid by the Corniferous limestone. The blank area on the map where the three railroads meet is a Corniferous synclinal possibly holding some Marcellus shale, but filled with the drift sand and clay on which Kingston is built: Esopus Creek enters this plain from the west and follows it for some miles northward; and farther on, the arch (or fault) which forms the western side of the synclinal, disappears, and the Corniferous and Marcellus trough is continued as a Marcellus monoclinal valley, occupied by the Kaaterskill on its northward course and crossed by the Catskill at Leeds.*

Glacial striæ were observed at several places with a direction

*See papers by the author in Appalachia, iii, 1882, 20; and Bull. Museum Comp. Zool., Geol. Series, i, 1883, 328.

S. 15° to 25° W. Unstratified drift, striated loose stones and erratics are uncommon; the most notable of the latter was found on the line of the West Shore railroad about one mile below the creek; it was a broken bowlder of a dense conglomerate in which the subangular pebbles were of jasper and quartzite.

Terrace flats cover most of the exposures at low levels, except where the creeks have washed them clean. In cutting out its path since the time of high water level when its old valley was much obstructed by sands, the Rondout has very clearly formed a new channel in the contorted Hudson River shales at Eddyville, the old channel being nearer the limestones. There is some appearance of another old channel south of the limestone outlier opposite Wilbur, but the present valley there is rather large for post-glacial cutting at so low a level.

The points of special interest that may be seen in one or two days' visit to Rondout are: first, the limestone bluffs and their deep quarries along the river, especially the quarry near the town showing the unconformity; second, the complication of synclinal and anticlinal on the line of the West Shore railroad; third, the new channel at Eddyville and the limestone synclinal opposite to it. A large quarry is opened on the river bluff a mile north of the map, and several others in a very interesting region between Whiteport and Rosendale southwest of our limits. Two railroads and the river boats afford easy access to the town; local tugs are constantly running up and down the creek between Rondout and Eddyville; and the Wallkill Valley railroad serves for longer excursions.

Cambridge, May, 1883.

ART. XLVI.—*Notice of Agricultural, Botanical and Chemical Results of Experiments on the Mixed Herbage of Permanent Meadow, conducted for more than twenty years in succession on the same land;* by D. P. PENHALLOW. Phil. Trans. Roy. Soc., Part IV, 1882. 4to.

IN 1880, Messrs. Lawes, Gilbert and Masters issued their report upon the first part of this valuable series of experiments under the head of "The Agricultural Results." Part II, now before us, embraces the "Botanical Results" and forms a voluminous publication of some 232 quarto pages, containing many carefully prepared and very detailed tables, showing the results obtained. The entire volume will well repay careful study, and even a hasty glance is sure to impress one, not only with the vast amount of time and care required to obtain and work up such results, but also with the necessity for giving

ample time to such work in order to avoid too hasty generalizations,—an error which is quite too liable to occur in this country at the present time, but which Messrs. Lawes and Gilbert, with characteristic caution, have avoided.

The experiments were commenced in 1856 upon thirteen plots of land, a number subsequently increased to a total of twenty-two. These plots were studied without manure, and under treatment with mineral and organic manures varying both in quantity and composition. "In the first years of the experiments it was observed that those manures which are the most effective with wheat, barley or oats grown on arable land —that is with gramineous species grown separately—were also the most effective in bringing forward the grasses proper in the mixed herbage. Again, those manures which were the most beneficial to beans or clover, the most developed the leguminous species of the mixed herbage, and *vice versa*. It was further observed that there was great variation in the predominance of individual species among the grasses and also among the representatives of other orders."

"Indeed, in the second year, 1857, the differences in the flora were so marked, that a first attempt was then made to separate and determine the proportion of each separate species, in carefully averaged and weighed samples taken from several of the plots at the time the crops were cut. . . . In these early trials the samples were separated into: 1. Gramineous herbage, stems bearing flower or seed; 2. Gramineous herbage, detached leaves and indeterminate stems; 3. Leguminous herbage; 4. Miscellaneous herbage," but these were afterwards reduced to three classes by combining the gramineous in one. "In all only eleven grasses, three leguminous plants and nine plants of other orders were then identified in the samples, though undoubtedly many more were present; and under the head of 'Gramineous herbage, detached leaves and indeterminate stems,' in one case as little as fifteen per cent, and in another more than fifty-three per cent of the total was recorded. This result at once illustrates both the difficulty of the work and the great difference in the character of growth on the different plots."

"From year to year the plots became more and more characteristic, and in the seventh season, 1862, it was decided to undertake much more complete botanical separations." For this purpose a botanical assistant was employed to take charge of the work, but "on each occasion, whether of more complete or of only partial separation, from three to six boys have also been occupied in the work."

The samples were taken by a collector who followed directly after the mowers until the whole plot had been cut. Each col-

lection thus made was well mixed on a cloth to prevent damage and loss, and from such a lot an average sample weighing from ten to twenty pounds was selected for final botanical analysis. The sample was weighed without delay and then spread out to dry, after which it was put away for future examination. "In the conduct of the separations, each worker had a small handful of the mixed herbage placed before him, which he separated into its various component species as far as he was able. From time to time the superintendent revised each of the so separated portions. But there always remained an undetermined residue, which varied in amount exceedingly, according as the herbage was simple or complex, stemmy or leafy, mature or immature, and so on. These at first undetermined residues, after some reduction in the hands of the superintendent, were next separated into portions of different character by means of coarse sieves of various gauges, by which the examination and the identification of the various components were much facilitated. Still . . . the amount of finally undetermined residue varied very considerably according to the description and the character of development of the herbage."

The details of observation were most carefully planned and thoroughly carried out, and were of such a nature as to cover the ground very fully. In the botanical separations, however, the fact that there always remained an undetermined residue would seem to imply that another method than the one employed might have given more accurate results. Doubtless, Messrs. Lawes and Gilbert had their own good reasons for the special course pursued, though they do not appear, but if the weighed samples had been separated while yet fresh, the exact determination of the species could then have been made at any future time, with certainty of avoiding, very largely at least, an undesirable element of error. Under such a course, there would have been little or no breakage; the species could have been more readily identified by unscientific assistants; the work could have been accomplished with greater ease and rapidity, and the undetermined residue would then have become very small, or have quite disappeared. Again, in comparing the production of the plots with the character of the seasons, sufficient importance does not seem to have been attached to local meteorological conditions as determined in the immediate vicinity of the experimental fields. In the tables given, the rain-fall is that recorded at Rothamstead, while the temperatures are all given as determined at Greenwich, and therefore not applicable in more than a very general sense. As has been shown on previous occasions, too much care cannot be taken in securing a local meteorological record in immediate connection

with experiments, where exact considerations of the influence of season are concerned.

It is interesting to note that, as the vegetation advanced under the influence of cultivation, the plants found on the plots came to represent a total of 22 orders, 63 genera and 89 species. The most numerous were naturally *Graminæ*, of which there were 22 species. Next in order were *Compositæ*, 13 species, followed by an almost equal number (10) of leguminous plants. In the miscellaneous orders the numbers ranged from six to one species each. As the authors remark, however, these figures do "not give any idea of the degree of predominance or of the absolute quantities of any particular species, or of the number of species on any individual plot."

Further general discussions deal with the "Antagonisms between plants;" the "Organisation by means of which they maintain or improve their position, or succumb in competition with others;" "Hostile competition," and other important con-

	Gramineæ and undetermined portions.	Leguminosæ.	Miscellaneous orders.	Total.
Without manure	1792·7	213·4	654·0	2660·0
400 lbs. ammonia salts alone	2652·1	8·3	496·2	3157·0
550 lbs. nitrate of soda alone	3436·5	14·1	893·1	4344·0
275 lbs. nitrate of soda alone	3184·0	33·6	929·7	4147·0
Mixed mineral manures with potash	2841·1	1010·6	702·8	4554·0
Superphosphate of lime alone	2053·1	128·6	732·3	2914·0
Mixed mineral manures without potash	2608·3	390·9	635·8	3635·0
400 lbs. ammonia salts with mixed mineral manures and potash	5191·3	10·7	672·0	5874·0
400 lbs. ammonia salts with mixed mineral manures, potash, and 2,000 lbs. cut wheat straw	5852·5	11·5	550·5	6414·0
800 lbs. ammonia salts with mixed mineral manures and potash	6268·6	0·5	329·7	6598·0
800 lbs. ammonia salts with mixed mineral manures, including potash and silicates	7041·6	0·0	216·2	7257·0
550 lbs. nitrate of soda and mixed mineral manures, including potash	5790·1	41·9	512·8	6344·0
400 lbs. ammonia salts and superphosphate of lime	3711·0	2·2	536·5	4250·0
400 lbs. ammonia salts and mixed mineral manures, with and without potash	4514·0	3·3	575·7	5093·0
Ammonia salts alone for 13 years, followed by mixed mineral manures each year since	2799·1	85·6	787·3	3672·0
275 lbs. nitrate of soda with mixed mineral manures, including potash	4440·3	282·2	699·8	5422·0
Farmyard manure alone	3404·5	141·6	758·7	4304·0
Farmyard manure and ammonia salts	4225·3	26·1	673·4	4924·0

siderations in connection with which the valuable observations of Hoffmann, Nægeli, Sachs, Nobbe and Darwin are cited. In-

teresting facts are also developed as to the relation of special fertility to predominance of certain species as determined by their particular habit of growth; e. g. whether deep or shallow rooted, etc., as well as many other details which can only be well appreciated by a careful study of the pages.

The most valuable results obtained are those which show the influence of different fertilizers upon the character of the vegetation and the total produce, since they give us a certain clue, reciprocally, to the character and fertility of the soil as indicated by the vegetation produced thereon, considerations which are of importance at the present time in view of the efforts being made to reclaim marsh lands and other areas now of little or no agricultural value. A close inspection of the tables given will be necessary to discover the interesting relations there shown, especially where the particular species is influenced, but the general results may be shown in the preceding tabular abstract which gives the means of the results in pounds per acre, for the years from 1862 to 1877 inclusive, as obtained from the various plots under different manurial treatment.

ART. XLVII.—*Mr. Backhouse's Observations on Physiological Optics;* by W. LECONTE STEVENS.

IN the Introduction to Helmholtz's Physiological Optics, the author states that he was often obliged to desist from his experiments on account of the distressing pain caused by them. The number of persons who are willing to meet the strain implied in a continued series of experiments with their eyes is at best small; and therefore I have read with some satisfaction the criticism on my work, which has recently been made by Mr. T. W. Backhouse, of Sunderland, England.

To use the eyes satisfactorily as instruments of research requires much practice, and Mr. Backhouse's admissions show that he has been laboring under some disadvantages. My own series of papers represented a succession of steps in a prolonged investigation, during which slight modifications had to be made regarding the relative importance at first attached to some of the elements which enter into our visual judgments. Mr. Backhouse disputes the efficacy of some of my explanations, but in opposition to them I do not find in his paper the record of any experiments that can be advanced as positive evidence in favor of any other explanations. He defends Brewster's geometric theory of binocular vision, but apparently without close examination of Brewster's own presentation of this. If the theory of

visual triangulation be admitted in any mathematical sense, vision by optic divergence is an impossibility, yet Mr. Backhouse admits my attainment of distinct binocular vision by optic divergence. Brewster elaborated his theory as so much pure geometry,* made no allowance for divergence of visual lines, and gave no indication that he suspected its possibility. He represented visual judgments as determined by the geometric relation between certain intersecting lines, saying "the line of visible direction does not depend on the direction of the ray, but is perpendicular to the retina,"† and that "distinct vision is obtained only on one point of the retina."‡ My experiments have proven that geometry has to be thrown out of consideration in this connection, and that the term "visual triangulation" is merely a misleading analogy. Mr. Backhouse does not deny the attainment of stereoscopy with optic divergence, but yet says "Brewster's theory is not contradicted by the experiments." Optic convergence accompanies most cases of binocular vision; but accompaniment and cause are not necessarily identical. The determination of locality by lines leaves no room for play of judgment. I have never underrated the importance of optic convergence as one of a number of elements that serve as data in the unconscious formation of visual judgments; but the intersection of imaginary lines may be safely discarded. Associated muscular action is an important element, but very far from sufficient by itself. Rapid and unconscious play of the eyes, as noted by Professor LeConte, is another important element in many cases, but by no means wholly sufficient, as is proven by my binocular experiments with spectral images. Regarding the metaphysics of corresponding retinal points discussion would probably be useless. I have repeatedly insisted upon the correspondence of certain retinal parts, but denied the strict mathematical interpretation of this given by Brewster. I can regard it only from the standpoint of evolution, as a product of experience, individual and ancestral.

Mr. Backhouse on p. 306 restates my threefold division of the elements of physiological perspective, including that of focal adjustment, and refers in a foot-note to my enumeration of the elements that are not physiological, but says that in the latter list "focal adjustment is somehow omitted." Since this element is exclusively physiological, the criticism is correct but perhaps unnecessary.

In his observations on the "phantom wall," the curvature of which was noticed but not explained by Brewster, Mr. Backhouse shows that his negative results are due to the insufficient

* See Edinburgh Transactions, vol. xv, Part III, p. 360.
† Brewster on Optics, p. 246. ‡ Ibidem, p. 50.

muscular power of his eyes. All strain is removed by resorting to the device described in my paper on that subject. He is mistaken in supposing that this involves any change of the conditions necessary for producing the appearance of curvature. The effect has been attained by many persons, including a number of well-known men of science.

In regard to the combination of points differing in retinal latitude, the only appeal is to experiment. My observations corroborate those of Professor Rogers and of Helmholtz. The nature of the experiment seems to have been misapprehended by Mr. Backhouse. It invalidates the theory of corresponding points, if any mathematical significance is to be attached to this theory.

My statements regarding stereographs of the sun and moon do not convey any exaggerated idea of the facts. By taking advantage of the sun's rotation and the moon's libration such stereographs have been obtained, and the binocular effects mentioned by me have been observed. My own examination of stereographs of the moon, and of other stereographs contrived as test objects, amply warranted me in accepting printed testimony regarding the stereograph of the sun, prepared by Mr. De la Rue. Unfortunately, the photographic negative was accidentally destroyed a few years ago, so that Mr. De la Rue was unable to furnish me a copy. My statement on this one point was therefore not based on personal inspection, but on my recognition of the entire accordance between the testimony on this point and my own oft repeated experience in such matters.

Brooklyn, Oct. 3, 1883.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Homologous Spectra.*—Hartley has continued his studies upon the spectra of allied elements, and has confirmed his supposition that elements of the same homologous series present either homologous spectra or homologous groups of lines in their spectra. He uses the word homologous here, to mean possessing an affinity depending on structure or constitution. Analogous resemblances in spectra had been observed by Mitscherlich, by Lecoq de Boisbaudran and especially by Cimician. The latter concludes that each natural group of elements has its own peculiar spectrum and certain lines and groups of lines recur with decrease or increase of wave-length for differences in the spectra of different elements of any one group. Almost every element has a number of feeble lines which bear the same relation to the chief line or lines which the over-tones in music bear to the funda-

mental note. An increase of wave-length of homologous lines of similar elements corresponds with a greater intensity of chemical kinetic energy. Hartley's photographs of the ultra-violet region completely confirm these views. Stoney had shown that the spectra of gases are to be referred to periodic motions within the individual molecules and not to the irregular journeys or encounters of the molecules with each other. The three hydrogen lines, *h*, F and C are the 32d, the 27th and the 20th harmonics of a fundamental vibration whose wave length is 0·013127714 mm. A harmonic relation exists also between the lines in the spectra of magnesium, zinc, cadmium, aluminum, and in calcium, strontium and barium when two octaves of the spectrum are examined. The fundamental vibrations appear to be in the infra-red region. In conjunction with Adeney, Hartley has accurately determined the wave-lengths of lines in twenty spectra. To study conveniently the harmonic relations between lines and groups of lines, it is necessary to map spectra according to their inverse wave-lengths or oscillation frequencies. In the spectrum of magnesium, there are three single lines, one pair of lines, four triplets, a quadruple and a quintuple group. In the zinc spectrum, a single line, a pair, three groups of triplets, a quadruple and a quintuple group; and the same for cadmium. Copper and silver each give two double groups, one sextuple and one septuple group. Aluminum three single lines alternating with three pairs. Boron two single lines and a pair. Silicon three single lines, three pairs and a septuple group. Maps of these spectra are given plotted in oscillation frequencies. These results in the author's opinion support the view that elements, whose atomic weights differ by a constant quantity and whose chemical character is similar, are truly homologous; or in other words are the same kind of matter in different states of condensation. He regards Lockyer's hypothesis "that every elementary substance may be decomposed into as many simple substances as there are rays in its spectrum" as quite incompatible with the theory that the spectra are composed of harmonic vibrations, since a compound body would give two or more series of harmonics related to two or more fundamental vibrations; and elements having a common component should give spectra in which the same series or groups of lines appear. In illustration Hartley gives the wave-lengths of certain lines in the copper and the tellurium spectra as follows: for copper 3307·4, 3290·2, 3280·5, 3273·6 (very strong), 3264·3, 3247·3 (very strong); and for tellurium 3307·5, 3290·0, 3280·4 (very strong), 3273·8 (very strong), 3264·4, 3247·2 (very strong). Both the substances were pure. Since the correctness of the measurements cannot be relied on beyond 0·1 tenth-meter, though they are believed to be correct to 0·2, it is impossible to say absolutely whether the above lines are or are not coincident.—*J. Chem. Soc.*, xliii, 390, Sept., 1883. G. F. B.

2. *On some Reactions of Tellurium.*—It is generally stated that tellurides in solution have a reddish-violet color. DEMARÇAY

however, finds that when pure they are slightly yellowish in color, the red-violet tint being due either to poly-tellurides or to some sub-oxide. If a strongly alkaline solution of a telluride be boiled with a reducing agent, phosphorus, hypophosphite, aluminum, etc., the violet color disappears to be replaced by a weak pale-yellow. If exposed to the air, the violet color reappears. If a tellurite be used in the above experiment the red-violet color is at first developed and then destroyed. If the solution is not sufficiently alkaline, a portion of the tellurium appears to be eliminated as hydrogen telluride. The formation of the violet compound appears to precede the formation of telluride, and may be due to the formation of a sub-oxide. The author also shows that Wöhler's tellurides of methyl and ethyl may be readily obtained by heating tellurium in powder for 48 hours in contact with methyl or ethyl iodide at 80° C. The two bodies unite to form dimethyl diiodide, which decomposes slowly at 100°, rapidly at 120°. From this, other derivatives are obtained.—*Bull. Soc. Ch.*, II, xl, 99, Aug., 1883. G. F. B.

3. *On Caucasian Ozocerites.*—Beilstein and Wiegand have submitted to an examination the ozocerite obtained from the island of Tscheleken in the Caspian Sea. It was a brownish-black sticky mass, which dissolved in boiling benzene leaving but a trifling residue. On adding alcohol, most of the paraffin was precipitated, leaving the admixed oils in solution. It was found better, however, to wash the crude material with ether, to remove the oil and coloring matter; and then to extract the residue with absolute acetic ether. The nearly colorless paraffin thus obtained was dissolved in boiling benzene, treated with animal charcoal, and precipitated by alcohol. By repeating this operation, a hydrocarbon was obtained in brilliant white crystals, and of constant fusing point, evidently homogeneous. To this substance, the authors have given the name *lekene*, from the island where it occurs. It constitutes the chief constituent of the Caucasian ozocerite. It melts at 79° and has a specific gravity of 0·93917. It dissolves readily in benzene, carbon disulphide and ligroin, less so in chloroform, ether and alcohol, and is quite insoluble in absolute acetic ether. Its solutions in hot benzene, carbon disulphide and chloroform gelatinize on cooling. On analysis it gave carbon 85·23, 85·1; hydrogen 14·72, 14·57; numbers not sufficiently close to determine between the formulas C_nH_{2n} and C_nH_{2n+2}. In vacuo it distils unchanged; but at atmospheric pressure it breaks up. Lekene is very permanent. Heated on the water bath for a week with nitric acid, or treated with chromic acid at 100°, it suffers no change. With acid chameleon solution of 4 per cent strength 500 c. c. were required with one gram of lekene to produce a permanent color; thus using three parts of oxygen to one of hydrocarbon, $(CH_2)+O_3=CO_2+H_2O$, and going to confirm the formula C_nH_{2n}. Fuming sulphuric acid converts lekene into a black crumbly mass, containing no sulphonic acids. Bromine gives crystallized substitution products.—*Ber. Berl. Chem. Ges.*, xvi, 1547, July, 1883. G. F. B.

4. *On the Fermentation of Cellulose.*—TAPPEINER has confirmed his assertion of a year ago, that cellulose is a fermentable substance, and now gives the results of his closer study of the phenomena attending it. When to a flask containing finely divided paper or cotton and a one per cent extract of meat, sterilized, a small quantity of the contents of the first stomach of a ruminant is added, a fermentation is set up by which the cellulose is brought into solution almost entirely. Upon examination it appears that two fermentations go on simultaneously, one evolving carbon dioxide and hydrogen, the other carbon dioxide and marsh gas, though both yield organic acids also. The latter goes on slowly for four weeks, evolving CH_4 and CO_2 in the ratio of 1 : 7·2, besides SH_2, H and N, at the beginning, and in the ratio 1 : 3·4 at the end. The remaining liquid, which had an acid reaction, was fractionated and yielded acetic aldehyde, acetic acid and other volatile fatty acids. The other cellulose fermentation, in which hydrogen is evolved, goes on when the neutral one per cent solution of meat extract is replaced: (1) by such a solution weakly alkaline; (2) by one diluted with an equal volume of water, containing in 100 parts HK_2PO_4 0·2 gram, $MgSO_4$ 0·04, $CaCl_2$ 0·02, called Nägeli's solution; (3) or by aqueous solutions which contain, besides the above mentioned salts, nitrogenous bodies, such as 0·35 ammonium acetate, 0·3 acetamide or 0·6 asparagin in 100 parts. With the second of the above named solutions, the gas evolved consists of 55·39 CO_2 with a small quantity of SH_2 and of 42·71 H, the difference 1·90 being nitrogen. A control-flask treated in precisely the same way, but containing no cellulose, evolved no gas. On examining the residue in the flask, the same bodies were detected as in the first fermentation. Hay, enclosed in a flask with air and water, evolves gases consisting of hydrogen and carbon dioxide and produces volatile acids. The author applies the facts he has observed to the phenomena of marsh gas formation from cellulose in ponds and marshes.—*Ber. Berl. Chem. Ges.*, xv, 1734, July, 1883. G. F. B.

5. *On the Splitting of Inactive Mandelic acid into two Isomers both optically active.*—LEWKOWITSCH has succeeded in proving conclusively that the optically inactive mandelic acid consists of equal portions of dextro- and lævo-rotatory mandelic acid, and in splitting the inactive acid so as to produce the active ones, and uniting the latter so as to produce the former again. Under the influence of fungoid ferments, this splitting takes place, one of the component acids being consumed by the plant. With *Penicillum glaucum*, the lævo-mandelic acid is destroyed, the dextro-mandelic acid remaining in solution. With *Saccharomyces ellipsoideus*, the dextro-mandelic acid is consumed and the lævo-mandelic acid is left. With cinchonine, the dextro-mandelate crystallizes out, leaving the lævo-mandelate in solution. The author proposes the name paramandelic acid, for the inactive acid thus formed.—*Ber. Berl. Chem. Ges.*, xvi, 1568, July, 1883.

G. F. B.

6. *On the Condition in which Carbon exists in Steel.*—ABEL and DEERING have made a series of experiments in the hope of obtaining information on the condition in which carbon exists in steel as it is left by the cold-rolling, as well as in its hardened, annealed and intermediate conditions. Two series of experiments were made. In the first series the steel was in the form of 12 disks 2·5 inches in diameter and 0·01 inch thick, each weighing about 6·5 grams. In one disk, hardened, the silicon was determined to be 0·20 per cent. A cold-rolled disk gave 1·108 total carbon, a hardened one 1·128, an annealed inside disk 0·924, and a similar outside one 0·860. Three disks were used for estimating the so-called uncombined carbon by gently heating them for three hours in 100^{cc} of hydrochloric acid of sp. gr. 1·10. The cold-rolled one left 0·096, the annealed inside one 0·052, and the hardened one 0·035 per cent carbon. Three others were placed in a cold saturated solution of potassium dichromate acidulated with $\frac{1}{10}$ of sulphuric acid, being supported on sieves of platinum gauze. The cold-rolled, the annealed and the hardened disk each left a small quantity of black particles which appeared spangly under the microscope and which were attracted by the magnet. Upon analysis the particles from the cold-rolled disk gave 1·039 per cent carbon and 5·87 per cent of iron; those from the annealed outside disk 0·830 and 4·74, and those from the hardened disk 0·178 and 0·70; calculated on the total weight of the disks. Thus the chromic acid treatment has left nearly the whole of the carbon from the cold rolled and the annealed disks in the form of a carbon-iron compound corresponding closely to the formula Fe_5C_2. But, on the other hand, in the case of the hardened disk only about one-sixth of the total carbon was left undissolved by the chromic treatment. The last disk was submitted to the action of a chromic solution containing a large excess of sulphuric acid. The black residue gave on analysis 0·84 carbon and 1·104 iron, showing that the carbide had broken down. To study the carbon-iron compound more carefully, and especially to learn (1) whether it is independent of the strength of the chromic solution, (2) whether the percentage of carbide in the steel is constant, and (3) how much of its carbon remains unconverted into hydrocarbons upon treatment with hot hydrochloric acid, a second series of experiments was made. The steel used was in the form of a thin sheet 0·008 inches thick, weighing 175 grams, cold-rolled from an ingot melted from cemented blister steel. On analysis it contained 1·144 carbon, 0·166 silicon, and 0·104 manganese. Four experiments were made, from 7 to 7·5 grams of steel being used in each, the strength of the chromic solution varying. The results seem to show that the material separated from cold-rolled steel by the action of chromic and sulphuric acid below a certain strength contains an iron carbide approximating to the formula Fe_3C or its multiple. Hence these experiments appear to sustain the view that the carbon in this steel is not simply diffused mechanically through the mass of steel but

exists in the form of an iron carbide, a definite product capable of resisting the oxidizing effect of an agent which exerts a rapid solvent action upon the iron through which the carbide is distributed. Future experiments must decide whether the carbide varies in its composition in different descriptions of steel similarly treated, though the experiments above given suggest that hardening diminishes the power of the carbide to resist the decomposing effect of the chromic solution.—*J. Chem. Soc.*, xliii, 303, June, 1883. G. F. B.

7. *A new fluid of great specific gravity, of large index of refraction and of great dispersion.*—C. Rohrbach describes the method of preparation of a solution of iodide of quicksilver and barium which possesses a great power of dispersion. At ordinary temperatures this solution is a clear fluid of a yellow color. The indices of refraction of various Fraunhofer lines were measured at the temperature of 23° C. by enclosing the liquid in a hollow Steinheil prism of 60° (*a*) and afterwards in a similar prism of 10° (*b*) (H_α, Na, H_β). The results are compared with those obtained from other well-known liquids in the following table:

		C	D	E	F	$n_F - n_C$	$\frac{n_F - n}{n_C}$
Water, 18, 75°		1·3320	1·3336	1·3357	1·3380	0·0060	0·0045
Bisulphide of carbon at 15, 65°		1·6219	1·6308	1·6439	1·6555	0·0336	0·0207
Oil of cassia		1·5979	1·6073	1·6207	1·6358	0·0379	0·0236
Faraday's heavy glass, G=4·728		1·7077	1·7148	1·7242	1·7325	0·0248	0·0145
Thoulet's iodide of quicksilver and potash, G=3·112		1·7014	1·7167	1·7391	1·7621	0·0607	0·0357
The same, G=3·2		----	1·733	----	----	----	0·0369
Iodide of quicksilver and barium G=3·564	*a*	1·7755	1·7932	1·8265	----	----	----
	b	1·7752	1·7928	----	1·8448	0·0736	0·0409

The strong absorption obscures the lines beyond G in the direction of the violet. The amount of the dispersion is shown by the indices of refraction of the components of the D line $n_{D_1}=1·7931$, $n_{D_2}=1·7933$. With a prism of 60° the angular difference between these components is fully 2′.—*Ann. der Physik und Chemie* No. 9, pp. 169, 174. J. T.

8. *Assumption of a Solar Electric Potential.*—Sir William Siemens, in his memoir "On the Conservation of Solar Energy," makes the hypothesis that the sun possesses a high electric potential which possibly produces the phenomenon of the zodiacal light. The existence of this electric potential is supposed to be due to the friction of the matter which on his hypothesis is drawn into the sun from space. Werner Siemens in a recent article calls attention to his observations on the electrization of the apex of the Cheops pyramid by the whirling dust clouds of the desert, as illustrating his brother's theory. "It is assumed that the body of the sun is conductive and is insulated by the sea of flame enveloping it. The photosphere retains one of the electricities

which have been separated by the friction while the other is spread by convection in cosmical space." The sun's electric potential then is supposed to act upon the earth's charge of free electricity. The dissipation of the earth's electricity, arising from the sun's distribution, is favored by the extreme rarefaction of the upper strata of air and by the ascending and descending currents of air loaded with moisture, since by these the free electricity is conveyed to the upper strata of highly rarefied air. The auroræ boreales and australes arise from the electrical compensation taking place at the boundary of the earth's atmosphere, between the matter flowing out from the sun charged with negative electricity and the liberated positive induced electricity of the earth. This exchange occurs principally in the polar regions, for the polar atmosphere is displaced by the strongly electrified air brought by the equatorial current in the upper regions of the atmosphere. Earth currents are also due to the electrical compensation which is continually going on. Mr. Siemens then refers to the investigation of Rowland upon the electrodynamic effect of a static charge of electricity when in motion and infers that the charge of the earth by its rotation is sufficient to produce the observed magnetism of the earth. He is apparently ignorant of the fact that Professor Ayrton and Professor Perry have made the same hypothesis and that Rowland in a subsequent paper has shown that the charge in the earth's atmosphere necessary to produce the observed magnetism of the earth would cause a spark to pass between the earth and the moon. Mr. Siemens regards thunder clouds as screens. As long as the particles of water constituting the cloud are at considerable distances from each other the cloud will be unaffected by the earth's electricity. Hence mist and light clouds will not become electric. But as soon as the particles of water come in contact with each other or so near to each other that electricity of high tension can leap from one drop to another the cloud is subjected to a distributive process which can be brought about or hastened by ascending vortices of clouds. By a copious formation of rain the water particles of the whirling vortices of clouds are brought closely together up to the highest air strata and it therefore becomes a conductor of electricity and is subject to electrical distribution. If at any place it is in conductive connection with the earth the electricity of the latter must flow into it. If it is not so connected it will become charged with electricity opposite to that of the earth while the similar electricity escapes by the conductive vortex cloud into the higher regions. The author of this theory suggests that astronomical investigations may show from the perturbations of the paths of Mercury, the asteroids and the satellites, the existence or non-existence of a solar electric potential.—*Phil. Mag.*, Sept. 1883, pp. 161–181. J. T.

9. *Cause of anomalous double refraction in some isometric Salts.*—The subject of the cause of the anomalous optical phenomena, observed in the case of many substances which appar-

ently crystallize in the isometric system, is one which has been widely discussed in the past few years. BRAUNS has made an important contribution to the subject by showing that in some cases the cause for this abnormal double-refraction is to be sought for in the variation in chemical composition occasioned by the presence of isomorphous compounds. For example, he finds crystals of potash alum and ammonia alum, which are chemically pure, to be absolutely isotropic, while crystals formed from a solution containing both salts showed distinct double-refraction. Similar results were obtained with crystals of lead nitrate and barium nitrate: when perfectly pure the crystals of each were isotropic, but the presence of a small amount of the isomorphous compound was accompanied by strong double-refraction. These observations supplement those of Klocke, who referred these optical phenomena to internal tension, by showing a cause why this tension should exist.—*Jahrb. Min.*, ii, 102, 1883. E. S. D.

II. GEOLOGY AND MINERALOGY.

1. *The Tortugas and Florida Reefs;* by ALEXANDER AGASSIZ. Mem. Amer. Acad., xi, for 1882, pp. 107–134. 4to, with 12 plates of maps and sections. June, 1883.—This memoir contains the results of a careful study of the Florida reefs by Professor A. Agassiz. The author sustains the view of Captain E. B. Hunt* that the long curving Florida reef, stretching westward from the southern extremity of this peninsula, has derived its form and its length through the drifting of calcareous (chiefly coral) sands by the current in the sea. Captain Hunt appealed to the sweep of the eddy counter-current along the reef region, thus making the reef, like any sand-reef, one growing by its extremity in the direction of the prevailing current, and not dependent on any progressing subsidence for its form. Mr. Agassiz presents various facts from the Tortugas and other parts of the reef which show that this view is adequate to account for the present condition of the reef and all its various features; and the facts are finely illustrated by the maps and sections. He adds to the above cause the fact that the warm current carried abundant food for the life of the reef, and urges that this cause must have generally had great influence in determining the distribution of coral reefs. Professor Agassiz further suggests that in the case of these and other coral reefs of the West Indies the bottom may have been brought up to within 50 or 100 feet of the surface where corals could begin to grow by the accumulations of calcareous relics made through the growth of other species or through uplifts of the sea-bottom and volcanic action. He mentions the occurrence of elevated coral reefs in Cuba, San Domingo and other West India islands, made chiefly of recent corals, as evidence that such upliftings have occurred; and states also that the Shell-limestone, or "Coquina," of St. Augustine, off portions of the east shore of

* This Journal, II, xxxv, 197, 1863.

Florida, north of Cape Florida (where no reef-making corals exist), is raised ten to twenty fathoms above the sea-level "at such points as Anastasia, Merritt's and Worth islands." The deposit is not known to be now increasing. Illustrations of the views presented in the memoir are drawn also from the Bahamas, the Yucatan reefs and from other parts of the same seas.

Professor Agassiz's observations in the West India seas lead him to question, as others have done, the view of Darwin that the atolls of the Pacific owe their forms largely to the conditions attending a progressing subsidence. It cannot be doubted that the causes acting in the American seas have acted alike in all coral reef seas; but they are adequate to produce like effects only under like conditions. The great depth of the seas of the Pacific reef region, the abrupt submarine sides of the atolls, the depth of the lagoons, in many cases, the resemblance between barrier reefs around high islands and atolls, amounting to identity of features, and the proofs of subsidence in many of the groups which the writer has elsewhere presented, make the question with regard to the oceanic atolls and reefs a very different one from that in the Florida seas. And even the sufficiency of the explanation for the Florida seas is not demonstration that subsidence has not been, to some degree, a factor in the case of other more eastern West India coral islands and in the Bermudas. When the question for the atolls has been studied by means of a series of borings to a depth of 500 or 1000 feet, which shall bring up the rock in a core six inches in diameter for examination, science will have positive conclusions as to the organic source of the reef limestone and as to the subsidence theory. Whatever the conclusions may be, geology is greatly indebted to Professor Alexander Agassiz for his careful and convincing investigations.

The writer has been misread on one point. He is made to share with Darwin in the view that Echinoderms were an important source of coral mud. But the fact is that he contests Darwin's conclusion, and, in opposition to it, makes trituration by the waves and currents the chief source of the mud as well as sand (Exped. Geol. Rep., 4to, 1849, p. 107, and Coral Islands, pp. 228, 229 and 340), saying that "fishes and Holothurians are quite inadequate for the supply," and that "the incessant grinding action about reefs accounts satisfactorily for the deposits of coral mud, however great their extent." J. D. D.

2. *Twelfth Annual Report of the U. S. Geological and Geographical Survey of the Territories of Wyoming and Idaho, for the year* 1878; F. V. Hayden, U. S. Geologist. Parts I and II. 504 and 810 pages, 8vo, with five large maps and numerous plates and wood-cuts.—These two volumes close the series of annual Reports of the survey carried on under the general charge of Dr. Hayden and the direction of the Secretary of the Interior—a survey that was fruitful in results to science and the country. In the letter of transmission of the Report now issued, Dr. Hayden speaks of five other volumes of the quarto series of reports as re-

maining unpublished, and adds that the general direction as to the completion and publication of these volumes has been committed to Major J. W. Powell, Director of the United States Geological Survey. This twelfth Annual Report contains Reports by C. A. WHITE on Cretaceous, Tertiary, Laramie, Triassic and Carboniferous fossils; Report by O. ST. JOHN on the Geology of the Wind River District; Report by S. H. SCUDDER on The Tertiary Lake Basin at Florissant, Colorado; Report on Crustacea by A. S. PACKARD; Report by R. W. SHUFELDT on the Osteology of *Speotyto cunicularia*, *Eremophila alpestris*, N. A. Tetraonidæ, *Lanius Ludovicianus*, and of Cathartidæ. Dr. White's Report is illustrated by 32 plates, Mr. St. John's by 49 plates; Mr. Scudder's by a map; Professor Packard's by 39 plates and a map; Mr. Shufeldt's by 24 plates; and the two last also by numerous wood-cuts in the text.

Part II is occupied with the geology and topography of the Yellowstone Park, and includes a general geological report by W. H. HOLMES, and a special report on the Thermal Springs and geysers by Dr. A. C. PEALE. Both are profusely illustrated and some of the plates are colored. Mr. Peale's Report has already been briefly noticed in this Journal.

3. *Report of the Second Session of the International Geological Congress at Bologna in* 1881. 664 pp. 8vo. Bologna, 1882. —A notice of the session of the Geological Congress at Bologna is given in volume xxiii (p. 150) of this Journal. The Report, issued under the supervision of the president, Professor G. Capellini, is a volume of great interest on account of the subjects discussed, and especially for its full, and in part illustrated, presentation of the reports of various national committees with reference to geological nomenclature and the colors and symbols of geological maps. The scheme of colors and symbols proposed in reports by Professor Heim, of Zürich, M. Maillard, of Paris, A. Karpensky, of St. Petersburg, and Professor Giordano, of Rome, are given in colored plates. These subjects are still under consideration, and the final decision on some points will probably not be reached before the next triennial session, that of 1884, in Berlin.

4. *Expedition to Rio Negro, Patagonia, in April, May and June*, 1879, under the orders of General D. JULIO A. ROCA. *Informal Official Report of the Scientific Commission.* (In Spanish). Third Part, *Geology*, by Dr. D. ADOLFO DŒRING. 4to. 1882. Work distributed by the National Academy of Sciences of Cordoba.—This Report treats briefly of the crystalline rocks, which are referred to the Laurentian and Huronian, though without giving any especial stratigraphical evidence as to age, and then takes up the Cenozoic formations, which are of great extent and rich in fossils. The subdivisions adopted are 1 (oldest), the Guaranitic, made to correspond to the Upper Cretaceous or Post-Cretaceous, and corresponding to the Laramie group and lower Eocene, and characterized by *Mesotherium;* the Patagonian or Oligocene, the upper containing *Megamys* and *Anoplotherium*,

the lower *Ostrea Patagonica;* the Araucanian or Miocene, containing *Nesodon* and *Anchitherium;* the Pampean or Pliocene, the lower containing *Typotherium*, the upper *Equus.* Above are the Tehuelche or Erratic formation—the Glacial; the Post-Pampean or Diluvial, and the Arian formation or alluvial.

5. *A Physical Survey in Georgia, Alabama and Mississippi, along the line of the Georgia Pacific Railway*, by Messrs. CAMPBELL and RUFFNER. 148 pp., 8vo, with two folded maps and sections.—This report is for the most part economical in its descriptions, but gives much geological information on the coal formation, including its stratification and flexures, and illustrates the geology of the country by a colored geological map.

6. *Use of solutions of high specific gravity in the study of rocks.*—The Sonstadt solution, of mercuric iodide in potassium iodide, is now in general use by lithologists as a means of obtaining a mechanical separation of the constituents of a rock. Its use, however, is somewhat limited because the maximum specific gravity obtainable (about 3·17) is less than that of some common minerals. ROHRBACH has recently shown that a solution of mercuric iodide in barium iodide, applicable for the same purpose, can be obtained whose specific gravity is as high as 3·58. This solution, although less convenient than the other because of its hygroscopic character, can be employed for the separation of many varieties of garnet, amphibole, pyroxene, also epidote, axinite, chrysolite, staurolite and other minerals, common in rocks, whose specific gravity is above that of the Sonstadt solution. The optical characters of this solution are described on an earlier page (406).— *Wied. Ann.*, xx, 169, 1883.

7. *Richellite: A new Mineral.*—MM. G. Cesaro and G. Despret have given the name *richellite* to a supposed new mineral from Richelle in the neighborhood of Visé, Belgium. It occurs in compact masses which have a cream-yellow color, becoming ochre-yellow on alteration. Luster greasy or resinous to earthy. Hardness between 2 and 3; specific gravity 2. An analysis gave the following results:

	P_2O_5	Fe_2O_3	Al_2O_3	CaO	ign.
(a)	28·67	28·71	1·80	5·64	35·54=100·36

At 100° the mineral loses 23·33 per cent H_2O, and at a red heat 6·10 H_2O and 6·11 HF. The authors leave the composition of the mineral in doubt, but regard it as a fluo-phosphate of iron and calcium, the fluorine being, in their view, in combination with the iron; the microscopic examination which the authors promise to make may throw some light upon the subject.—*Ann. Soc. Belg. Mem.*, x, 1883.

8. *Classification of Meteorites.*—Professor TSCHERMAK, who has made many important contributions to the study of meteorites, has been led by the results of recent microscopic study to propose some changes in the system of classification given by Rose in 1864. The meteorites are classified after the principles of lithology according to the kind and relative amounts of their

mineralogical constituents. The classification as proposed by Tschermak, with some typical examples under each head, is as follows:

I. Meteorites consisting essentially of iron: *Meteoric iron.*

II. Meteorites having an iron ground-mass with enclosed silicates. (*a*) *Pallasite:* iron and olivine the chief constituents (Pallas-iron, Atacama, Bitburg); (*b*) *Mesosiderite:* iron with olivine and bronzite (Hainholz, Estherville); (*c*) *Siderophyr:* iron and bronzite (Rittersgrün, Breitenbach, Steinbach); *Grahamite:* iron with plagioclase, olivine, bronzite (Sierra da Chaco).

III. Meteorites consisting chiefly of olivine and bronzite with iron as a subordinate constituent; the texture mostly chondritic. *Chondrite* (Aigle, Knyahinya, New Concord, Pultusk).

IV. Meteorites consisting essentially of olivine, bronzite or pyroxene. (*a*) *Chassignite:* olivine (Chassigny); (*b*) *Amphoterite:* olivine and bronzite (Manbhoom); (*c*) *Diogenite:* bronzite or hypersthene (Ibbenbühren, Shalka); (*d*) *Chladnite,* enstatite (Bishopville); (*e*) *Bustite:* diopside and enstatite (Busti).

V. Meteorites consisting essentially of augite, bronzite, lime feldspar; with a shining crust. (*a*) *Howardite:* augite, bronzite, plagioclase (Frankfort, Loutolaks); (*b*) *Eukrite:* augite, anorthite or maskelynite (Juvinas, Jonzac, Stannern, Petersborough). —*Ber. Ak. Wien.*, July 7, 1883.

III. Miscellaneous Scientific Intelligence.

1. *The British Association at Southport.* — The President, Professor Cayley, commenced his inaugural address by a brief mention of three distinguished members of the association who had died during the year past, Professor Henry John Stephen Smith, General Sir Edward Sabine and William Spottiswoode, and then proceeded with his subject — obligations of pure mathematics to other sciences as the sources of mathematical theories. The address of Professor O. Henrici, president of the Mathematical and Physical Section, was also mathematical, his subject being pure geometry. Mr. J. H. Gladstone, president of the Chemical Section, spoke on the nature of the so-called elements; Professor W. C. Williamson, president of the Geological Section, on the vegetation of the Coal period; Lieut.-Colonel H. H. Godwin Austen, of the Geographical Section, on the Himalayas; and Mr. Wm. Pengelly, president of the Anthropological Section, on Cavern researches. Professor Williamson remarked on the strange fact that while extremely delicate cell-structures are preserved in the Carboniferous beds, no terrestrial cellular Cryptogams have been found in them except a few imperfect Fungoid relics. In the course of his review of the relations of the genera of Coal plants, he observed that *Calamodendron* and *Calamites* are the same in type and both Equisetaceous; that one tall and slender *Calamites,* found at the Moorside Colliery, near Ashton-under-Lyne, proved on measurement by him to be 30 feet

in length and 6 inches in diameter at one end and 4½ at the other; that the *Sigillariæ* and *Lepidodendra* are alike lycopodiaceous and Stigmaria the true root of either; that these ancient lycopodiaceous plants, and also the Calamitean, even slender kinds, develop a secondary exogenous growth of vascular tissue-making zones and so giving strength to the exterior, and that on this structure was based the reference of the Sigillariæ and the Calamodendron to the Gymnosperms; that *Haloniæ* are not the roots of Lepidodendra or other plants; that the *Trigonocarpa*, *Cardiocarpa* and *Cordaites* are Cycadean, as well shown by Grand-Eury and others; that exogenous plants are represented by stems or branches, named by him *Astromyelon* (more or less aquatic since it closely resembles those of *Myriophyllum*, *Marsilea*), *Heterangium Grievii*, and *Lyginodendron Oldhamium*, a plant that attained arborescent dimensions.

The president of the Biological Section, Professor E. Ray Lankester, spoke of the small amount of scientific research in Great Britain and of encouragement toward it by the government, compared with the same in the nations of the Continent, especially Germany, and by way of contrast, of the condition and character of the systems of education in German universities. He closed with remarks on "a reasonable and proper method of removing, to some extent, the defect in British national life due to the want of provision for scientific research."

The addresses are published in numbers 725, 726, 727 of Nature, and other proceedings of the Association in following numbers.

At the next meeting of the British Association, in Montreal, Lord Rayleigh will be the President, and the Marquis of Lorne, Marquis of Lansdowne, Sir Charles Tupper, Sir A. T. Galt, Professor Huxley, the Right Hon. Lyon Playfair, Principal Dawson and others, Vice-Presidents.

2. *Greenland ice.*—Nature of September 27 and 28 (Nos. 726, 727) states that the inland ice party of Baron Nordenskiöld started on July 3 from Auleitswikfjord. At a point eighty miles east of the glacier border and 5,000 feet above sea-level they were prevented by soft snow from proceeding with sledges; and Laplanders on snowshoes were sent on from this point, who penetrated 130 miles eastward over unbroken snow to a height of 7,000 feet. Over the whole inland there is ice. With the ice occur masses of fine dust, which is partly of cosmical origin. The party consisted, under Nordenskiöld, of Dr. Berlin, Sergeant Kjellström, Herr Johannesen, two hunters, Sevalsen and Kræmmer, two sailors, and the Lapps, Anders and Lars. The journey lasted a month.

3. *U. S. Coast and Geodetic Survey for* 1881, J. E. Hilgard, Superintendent.—The memoirs presented in the appendix to this Report are the following: On type-forms of topography, Columbia River, by E. Hergesheimer; Collection of results for declination, dip, and intensity, from observations by the survey be

tween 1833 and 1882, pp. 159–224, by C. A. SCHOTT; Barometric hypsometry and reduction of the barometer to sea-level, Part III, by Wm. FERREL; Report on the oyster beds of the James River, Va., and of Tangier and Pocomoke Sounds, Md. and Va., illustrated by maps and plates, by Lieut. F. WINSLOW; On the length of a nautical mile, by J. E. HILGARD; On a method of readily transferring the underground mark at a base monument, by O. H. TITTMANN; On the flexure of pendulum supports, by C. S. PEIRCE; On the deduction of the electricity of the earth from pendulum experiments; On a method of observing the coincidence of vibrations of two pendulums, by C. S. PEIRCE; On the value of gravity at Paris, by C. S. PEIRCE; New rule for tides in Delaware Bay, by H. MITCHELL.

Besides these papers the appendix contains a "*General Index* of scientific papers, methods and results contained in the appendices to the Annual Reports of the U. S. Coast and Geodetic Survey, from 1845 to 1880 inclusive," by C. H. SINCLAIR, which, on account of the great value of the papers, will call forth the hearty thanks of all interested in the progress of science.

Hydraulic Tables for the Calculation of the Discharge through Sewers, Pipes and Conduits, based on Kutter's formula, by J. P. Flynn, Civil Engineer. 136 pp. 16mo. New York, 1883 (D. Van Nostrand).

Phytogeogenesis. Die vorweltliche Entwickelung der Erdkruste und der Pflanzen in Grundzügen dargestellt von Dr. Otto Kunze. 214 pp. 8vo. Leipzig (Paul Frohberg).

Report of the Mineral Resources of the United States for 1882 and the first six months of 1883, by Albert Williams, Jr., U. S. Geological Survey. 814 pp. 8vo, 1883.

A Summary of the Geology of the Comstock Lode and the Washoe District, by GEORGE F. BECKER. Extr. from the Ann. Rep. U. S. Geol. Survey, 1880–81. pp. 293–330, with colored maps. Washington, 1881.

Geological Survey of Illinois, A. H. Worthen, State Geologist. Vol. VII. 374 pp. 8vo, with 31 plates. May, 1883.

Lehrbuch der vergleichenden Anatomie der Wirbelthiere auf Grundlage der Entwicklungsgeschichte, by Prof. Dr. R. Widersheim. 2nd part (and last), 477–908 pp., June, 1883 (Gustav Fischer).

OBITUARY.

JAMES LAWRENCE SMITH.—Dr. J. Lawrence Smith died at his residence in Louisville, Kentucky, on the 12th of October. He was born near Charleston, South Carolina, on the 16th of December, 1818, and was therefore in his 65th year. He was a graduate of the University of Virginia and of the Medical College of Charleston. After leaving the latter institution he spent three years in Europe, and mostly at Paris, pursuing studies in medicine, physics, chemistry, geology and mineralogy. While in Paris he commenced his publications in chemistry by a paper on the means of detecting arsenic in the human body, which was republished in vols. xl and xlii of this Journal (1841, 1842). After his return to Charleston, which took place in 1844, he became Assayer of the State, studied its marls, ores and cotton-bearing soils; and his able report on cotton-growing led to his appointment under the Turkish Government with reference to instruction

on the subject in that country. The emery mines of Turkey gave him a new subject for research; and his report on them is the first full account of the geological character and mineralogy of an emery region that had appeared. Besides a careful chemical study of the emery, in the course of which he devised the mode of attack of this refractory material by sodium bisulphate, he investigated its effective hardness by a new method and extended his determinations to the emery of other localities. The memoir was honored by the French Academy, to which it was presented, by publication in the *Mémoires des Savants étrangers.* Dr. Smith afterward studied the emery of Chester, Massachusetts, in which he confirmed and extended his previous observations on the mineral and its mode of occurrence and mineral associates. Dr. Smith published also a chemical report on the Thermal waters of Asia Minor.

American mineralogy owes very much to Dr. Smith for his careful chemical investigations, the earlier of which were carried on conjointly with Professor Brush; and the science of Chemistry in many ways, and especially for the method proposed by him, and since adopted generally, for the determination of the alkalies in silicates. Many ingenious appliances were proposed by Dr. Smith in the department of chemistry and physics; one of the most important is that of the inverted microscope. Meteorites were with Dr. Smith a subject of great interest and of thorough study. His papers giving descriptions and the results of his chemical and physical investigations of different meteoric stones and irons are very numerous, and have advanced greatly this department of science. It was the topic of his last paper, which appeared in this Journal in June of the present year. Dr. Smith published in 1873 a volume containing a collection of his papers to that date, and out of the 400 pages, 100 are devoted to his papers on meteorites.

Dr. Smith held for some years the position of Chemistry in the University of Virginia, and, during the later years of his life, that of Chemistry in the University of Louisville. His very large collection of meteorites with that also of minerals was given by him two years since to the Polytechnic Society of Louisville. He was a member of various scientific academies, both foreign and American, and was recently honored with a foreign membership of the Academy of Sciences of Paris. One who well knew him in his adopted city says justly of him: "Eminent in his profession, he was more than eminent in his home. He was a gentleman, truly, but he was a man of affairs, a man of convictions, a man among men, who, though absorbed in scientific pursuits, took a sincere and profound interest in public questions and events. He had not an enemy on earth, despite the positivity and transparency of his opinions, and he goes to his last rest leaving the people with whom he was so long identified to mourn the loss of a citizen of whom all were proud and whom everybody loved and honored."

WM. A. NORTON.—The death of Professor Norton, of the Sheffield Scientific School in Yale College, is announced on page 332 of this volume. As the principal portion of his contributions to science have appeared in this Journal we need only give a general statement of their character and extent. His earliest memoir was in the 46th volume of the first series, and was on the mode of formation of tails of comets. The manner of action of a solar repulsion in producing the comets' tails was developed at length. Some of the ideas, though original with Professor Norton, had been anticipated by Olbers and Bessel. A series of papers followed upon the relations between the distribution of heat on the earth and the phenomena of terrestrial magnetism.

From these he was led on to further discussion of magnetic action over the earth, and of like action, as he argued, in the body of the sun and in the formation of the comas and tails of comets. These papers included especially an elaborate discussion of the famous comet of 1858.

After this followed a series of papers on molecular physics, in which, starting from a few elementary assumptions, he arranged in one system the various phenomena of physics, explaining the gaseous, liquid and solid forms of matter, the various phenomena of electricity and magnetism, of light, heat, attraction, crystallization and chemical action; also explaining terrestrial, cometary and solar physics, the whole worked out in detail. Many of his conceptions and arguments are in direct opposition to widely accepted theories. But if some, or even if all of them shall, in the end, fail to be accepted as truths of nature, yet these memoirs will continue to testify to his love of truth, his painstaking labor and his complete grasp of the problems to be solved.

Professor Norton graduated from West Point in 1831, and for the next two years held the position in the Military Academy of Professor of Natural and Experimental Philosophy. He then resigned from the army, and accepted a similar position in the University of the City of New York. He was afterward connected with Delaware College at Newark, Delaware, first as Professor and then as President, and subsequently with Brown University at Providence, Rhode Island, as Professor of Natural Philosophy and Civil Engineering. Since 1852 he has been Professor of Engineering in the Sheffield Scientific School, and since 1873 a member of the National Academy of Sciences. Commencing his work at the Sheffield Scientific School when it consisted of but two professors besides himself, he contributed largely, by his faithful labors and excellent judgment, to its development and success.

Dr. OSWALD HEER, the distinguished author of works on fossil plants, and the most prominent of investigators of Arctic species, died at Lausanne on the 27th of September, aged 74 years.

JOACHIM BARRANDE, the eminent paleontologist, died in October at Prague, in his 84th year.